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# Development of an online food safety training and pilot study for employees of university farms and school gardens

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**Development of an online food safety training and pilot study for employees of  
university farms and school gardens**

by

**John Michael Dzubak**

A thesis submitted to the graduate faculty  
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Major: Food Science and Technology

Program of Study Committee:  
Angela Shaw, Major Professor  
Aubrey Mendonca  
Catherine Strohbehn

Iowa State University

Ames, Iowa

2015

DEDICATION

*Dedicated to Mom, Dad,  
and Allison*

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## NOMENCLATURE

CDC	Centers for Disease Control and Prevention
EPA	Environmental Protection Agency
FSIS	Food Safety Inspection Service
FSMA	Food Safety Modernization Act
GAPs	Good Agricultural Practices
GHPs	Good Handling Practices
GMPs	Good Manufacturing Practices
HACCP	Hazard Analysis Critical Control Points
USDA	United States Department of Agriculture
WHO	World Health Organization



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## ABSTRACT

Two one-hour on farm food safety online module were developed to inform k-12 students and university farm workers on food safety hazards associated with production and harvesting of fresh produce. Module content was developed through a review of the current Good Agricultural Practices (GAPs) Program, current research available, and updated regulations in produce food safety. Quizzes for students and a user manual were created for facilitators and instructors to support the online modules. After developing the course materials, a pilot study was conducted at two k-12 school districts in Iowa, two land grant universities, with a six member expert steering committee panel to test the knowledge gained through the two developed curriculum. The six member expert steering committee along with three other facilitators completed an online survey consisting of open-ended questions to determine the effectiveness of the online module and the supporting materials available on the inclusive webpage. The hypothesis of this research is that the online curriculum and supportive material will be beneficial to both demographics, and increase in knowledge will be observed after viewing developed material.

Students and university survey results indicate that the online module will significantly increase the knowledge of students and university workers related to hazards associated with produce food safety ( $P<0.05$ ). The topics, graphics, design, length, and webpage were appropriate for the age group. Additionally, the resource guide and quizzes were perceived as helpful and will be useful to increase the knowledge and confidence of the training facilitators ( $P<0.05$ ). The group indicated that specific graphic

and content material changes should be made within the module. This online module is a first step toward educating youth about food safety in the garden. Knowledge on hazard prevention can reduce the risk of produce contamination and decrease produce outbreaks from occurring in school gardens.

## CHAPTER I: INTRODUCTION

Food safety is a continuing concern in the fresh produce industry. A majority of fruits and vegetables are consumed raw, with no intervention strategies to kill harmful pathogens that may be present on the produce when harvested. Between 1998-2008, 46% of total reported foodborne illness cases were attributed to fresh produce and nuts, of which 22% were due to leafy vegetables (Painter et al., 2013). Produce foodborne illness is of concern for school gardens, as close to 24,000,000 children are involved in farm to school programs in the United States (USDA FNS, 2014).

There are currently many different produce food safety resources and trainings available online for school gardens and university farms. These resources include checklists, examples, logs, or activities that inform garden workers on different food safety hazards and hazard prevention techniques while working with fresh produce (Oregon Department of Education, 2013; Denver Urban Gardens, 2007; University of Nebraska Extension, 2005; Penn State Extension, 2015; North Carolina University A& T State University Extension, 2011; Clemson Extension, 2015; The Ohio State University Extension, 2015; Colorado State University Extension, 2013; Utah State University Extension, 2008; Cornell University Extension, 2015; University of Maryland Extension, 2015; Delaware Cooperative Extension, 2009; University of Illinois Extension, 2015; Rutgers Extension, 2015; Michigan State University Extension, 2009; University of Massachusetts Amherst, 2015; West Virginia University Extension, 2015; University of Georgia Extension, 2012). These trainings are recommended by the FDA to take a minimum of 8 hours in length to have a full understanding of Good Agricultural Practices. An example of such a program is the North American Colleges & Teachers of

Agriculture (NACTA) collaboration with Cornell University on a three-week long course offered through the National GAPs Program. This course requires between fifteen to twenty hours to complete (NACTA, 2014). Their course offers more in-depth information and is recommended for managers and instructors teaching our course. When looking at other programs, there is no short comprehensive, on-line program currently available that focuses on providing training for employees and the youth workers. Our program was developed for students working in school gardens and for university farm workers to alert them of hazards and hazard prevention techniques to reduce risks of produce foodborne illness. It can be completed within one hour and is based off of the National GAPs Program, current research findings, and updated regulations in the fresh produce industry.

University farms are used for research, teaching, and outreach activities around the United States. Remaining fresh produce will be shipped out to local consumers or used in university lunch programs. However, many farm workers handling produce directly don't realize or consider that fresh produce will reach the consumer. With reduced focus on produce safety, there is a higher risk that contaminated products can reach at risk consumers. Additionally, these farm workers may be lacking knowledge on produce food safety because they have never received proper employee training.

This thesis study focuses on two aspects in the development of food safety comprehensive online curriculums in school gardens and university farms, in which all information needed to complete training is available on one webpage. The first aspect of research focused on the development of inclusive food safety curriculums for school gardens and university farms. A pilot study was performed in the second phase of the

study to test effectiveness of information presented in the developed material. The research hypothesis of this study is that there will be an increase in knowledge after viewing the developed material (accessed through pre- and post- knowledge surveys). Research results provide information on benefits of online curriculums, determine if knowledge increases are observed after viewing the developed material, and whether or not knowledge increases will influence behaviors of trained individuals of school and university gardens.

### Justification of Research

This research project is essential with the current knowledge gaps with school garden and university farm workers. The developed training guides aim to address the major contributing factors that can increase the foodborne illness risk with fresh produce items. Upon completion of online training, school garden and university farm workers will gain knowledge in methods to reduce food safety risks in fresh produce items.

Additionally, this online program provides interactive modules, knowledge quizzes, additional activities, and an instructor resource manual found on a single webpage. The reason for online production was to allow for mass distribution and to serve as distance education resource. Dissemination of these developed resources will assist FFA and 4-H educators, school district nutritional programs, higher education farm managers, and local foods coordinators.

Piloting the developed materials will indicate whether or not the online training programs were beneficial in increasing knowledge of produce food safety hazards. The results from the pilot study will also inform our team on whether or not the developed material is understood in different regions of the country. By developing an online



curriculum and testing the material through a pilot study, we can determine if our material is appropriate for each demographic and whether or not knowledge increases are observed after viewing the training program.

## CHAPTER 2: REVIEW OF LITERATURE

### Introduction

Recent years have shown dramatic increases in school gardens and university farms. In 2014, The United States Department of Agriculture (USDA) Food and Nutrition Service completed a national census showing 40,328 schools with a farm to school program in place, with close to 24,000,000 children involved in these schools' programs (USDA FNS, 2014). To meet the needs for research in fresh produce, university farms are also in place all across the country. With this increase in gardens and farms, per capita production or consumption of fresh produce in the United States in all seasons has increased (Beauchat, 1995). The total annual average of fruit consumption was 12% higher than that in the 1970s, and vegetable consumption was 23% above the annual average from the 1970s(USDA, 2001). The increase of fresh produce consumption has been linked with consumers fighting the obesity epidemic. This affects many school, community, and university gardens because these operations will help supply their surrounding communities with fresh produce that was grown and harvested in those fields. With an increase in fresh produce production, there is also concern for an increase in foodborne disease if produce isn't properly processed, or is exposed to harmful agents. Many farm workers are focused on research goals and aren't focused on the safety of the produce that ultimately reaches consumers. Additionally, farm workers may not have knowledge on produce food safety handling during the production and harvesting steps of their crops.

A significant portion of food products that result in foodborne illness include fresh produce items. From 1998-2008, 46% of reported foodborne illness cases were

attributed to fresh produce and nuts, with 22% of these due to leafy vegetables (Painter, 2013). Specific pathogens of concern when considering fresh produce include bacteria of *Aeromonas hydrophila*, *Campylobacter jejuni*, *Staphylococcus aureus*, *Escherichia coli*, *Salmonella sp.*, *Shigella sp.*, *Plesiomonas shigelloides*, *Vibrio cholera*, *Bacillus cereus*, *Clostridium botulinum*, and *Listeria monocytogenes* (Brackett, 1999). Viruses and parasites are other forms of foodborne illness that can contribute to foodborne illness. The viruses and parasites that have contributed the most to foodborne disease include norovirus, *Giardia lamblia*, *Toxoplasma gondii*, Astrovirus, Rotavirus, *Cryptosporidium parvum*, *Cyclospora cayetanesis*, Hepatitis A virus, and *Trichinella spp.* (Tauxe, 2002). Higher risk of pathogenesis occurs in ready to eat foods; when crops are unlikely to be cooked prior to ingestion (Nicholson, 2005). Foodborne illness in humans will then result when a susceptible host ingests viable pathogens or toxins from contaminated food (Lammerding, 2000).

Students, workers, and volunteers will handle these freshly harvested produce items, which could end up reaching high-risk populations (Children under 5 years old, elderly, pregnant, and immune-compromised). Fresh produce items harvested from a school garden will reach young students in the school that may not have fully developed immune systems. Produce items from university farms will be sent out to retail for consumers, all of whom may have immune deficiencies. To reduce foodborne illness risk, appropriate training for instructors, students, volunteers, and university farm employees that handle fresh produce is needed to increase overall confidence and knowledge of potential physical, chemical, and biological hazards and reduce the likelihood of foodborne illness from occurring within these at risk demographics.

## School Gardens

There have been many reasons for garden increases in schools across the United States. The school garden movement initially started in 1918, with the primary focus on food production (Subramaniam, 2002). Since then, school gardens have shifted to a different perspective, including: broadening child experience of the ecosystem and teaching food systems ecology (Blair, 2009). Fresh produce developed in school gardens can be used in the cafeteria, and incorporated into school lunches (USDA FNS, 2015). Produce grown in school gardens may also be taken home with students or be sold in school farmers markets (Denver Urban Gardens, 2010). Additionally, personal experience with nature will help increase child learning from within the classroom (Nebhan & Trimble, 1994). Implementing a fresh produce curriculum in schools will give children more hands-on experience with fresh produce, which can change behaviors in eating habits. Teaching garden practices in the classroom can help broaden overall perspectives of children, and potentially decrease the current obesity epidemic (Blair, 2009).

Studies have been performed to see if school gardens impact knowledge, attitudes, and behaviors of students in relation to fresh produce. A study performed at the University of Berkeley evaluated the School Lunch Initiative over a three-year period to see if exposure would change student knowledge in nutrition; attitude changes; and behaviors toward fresh produce. Results from this study showed knowledge in nutritional aspects were higher, students had a positive attitude about fresh produce, and behaviors changed with increases in fruit and vegetable consumption by more than 1 serving per day (Wang, 2010). Morgan (2010) found that nutrition education in

elementary schools positively impacted students' willingness to consume vegetables. Implementing garden based programs into primary school curriculums has shown that positive attitude changes can be observed in actively involved students. Another pilot study was conducted by Fahlman (2008) with middle school youth. Results showed that the group exposed to nutrition information had significant increases in knowledge and behaviors. These studies have all shown that positive changes in attitudes and behaviors can occur in younger aged students when implementing training programs.

As beneficial as school gardens have shown to be for the schools, community, and students, there are still limitations with development and usage of these gardens. Some of the main limitations include volunteer presence in and around the gardens, teachers' knowledge, and students' training. Implementing training programs for school gardens can help increase knowledge of individuals working in the garden, can provide more knowledge and confidence for teachers running school gardens, and can provide students with adequate information on how to safely harvest and store fresh produce items, with ultimate outcome of risk mitigation.

### University Farms

University farms serve many different purposes. One of them includes growing fresh produce to supply campus dining centers. Additionally, fresh produce grown on university farms can be used in local restaurants (Iowa State University, 2008).

University farm programs can help educate students and faculty on local food production and sustainability (Case Western Reserve University, 2015). University farms help support teaching, research, and outreach activities related to agriculture. The hands-on experiences incorporated into classes help students planning on continuing careers in

agriculture (Illinois State University, 2015). Besides selling to campus dining centers, some of the fresh produce may be sold seasonally to other areas on campus, and to the local community. University farm operations may do more than supply fresh produce to these groups; they also help support local farmers, provide the community with garden education, and train students on sustainability and production. Students learn how to manage and research university gardens in a safe manner (California State University, 2015). However, many of these farm workers are specifically research guided and don't always focus on the safety aspects of fresh produce. Farm workers handling these items may not have knowledge on good agricultural practices while producing or harvesting crops.

Similar to school gardens, there are also limitations to university farm operations, including lack of proper employee training, appropriate documentation, and potential cross-contamination of product from the worker. Fresh produce items not used for research or dining centers from university farms may be distributed to community or retail markets; outlets which potentially reach high-risk populations (young, elderly, pregnant, immune compromised). Thus, making implementation of training programs to university farm programs to reduce risks from fresh produce items is essential.

### Current Educational Options

Current training methods for workers of school gardens and university farms include workshops, hands on activities, and interactive online courses and tools. On-site training and classroom-based training methods are used to educate workers and students on good agricultural practices, with heavy emphasis on food safety. However, these options take more time to complete, which could exceed the time availability for workers

and students. Some of the activities that can be included in farm to school programs include in-class curriculum, growing fresh produce in the garden, using the gardens as part of teaching, and taking field trips to farms. Adding a farm to school program into the curriculum allows for additional incorporation of math and science into the curriculum, and real world application to scientific topics.

School gardens across the country are incorporating online tools that help garden managers regulate how the garden is prepped prior to starting the garden, and weekly practices to perform while working in and around the garden. University farm trainings are also becoming available, offered online or in person, and facilitated by either expert professors or industry professionals. Trainings for university farm workers have strong food safety emphasis, with fundamental principles in GAPs, GMPs, and overall HACCP programs. Many university extension and community gardens have contributed in providing online checklists, logs, and activities to inform workers about food safety risks associated with fresh produce and steps they can take to mitigate these risks (Oregon Department of Education, 2013; Denver Urban Gardens, 2007; University of Nebraska Extension, 2005; Penn State Extension, 2015; North Carolina State, 2015, North Carolina University A&T State University Extension, 2011; Clemson Extension, 2015; The Ohio State University Extension, 2015; Colorado State University Extension, 2013; Utah State University Extension, 2008; Cornell University Extension, 2015; University of Maryland Extension, 2015; Delaware Cooperative Extension, 2009; University of Illinois Extension, 2015; Rutgers Extension, 2015; Michigan State University Extension, 2009; University of Massachusetts Amherst, 2015; West Virginia University Extension, 2015; University of Georgia Extension, 2012).

Even with these training options and resources available for school gardens and university farms, a majority of workers on university farms have performed minimal to no food safety training. Many steps in pre-harvest and post-harvest production can impact produce food safety. Risks associated with fresh produce make training necessary for those involved in its production and distribution. Fresh produce can pose high food safety risks to consumers exposed to them, including biological, chemical, or physical agents in food that can result in adverse health effects (Manning, 2013).

### Online Education

Online learning is becoming more common in educational settings. Because there have been diverse terms used across different disciplines, it is a challenge to have a specific definition for online learning, including web-based learning, distance learning, e-learning, and Internet learning (Ally, 2004).

Allen (2010) proposed different classifications for online courses depending on the amount of material presented online versus in the classroom. The four categories include Traditional, Web facilitated, Blended/hybrid, and Online. Traditional courses are courses that contain 0% of material delivered online. Web facilitated courses use web technology to convey course material, but only 1-29% of total coursework is online. Whereas in blended/hybrid courses, 30-79% of material is delivered online. For online courses, 80+% of material is delivered online, with typically no face-to-face meetings.

The teaching theory for computer-based learning has shifted over time. Initially, online education was based on a behaviorist approach. The behaviorist approach thought that learning was a change in behavior caused by external stimuli in the environment, and that the observed behavior showed whether or not the learner had gained knowledge



(Skinner, 1974). With the heavy emphasis on observation, the behaviorist theory did not emphasize internal aspects of learning. This theory viewed the learner more as a passive responder than an active participant (Dierking, 1991). However, many instructors argued that not all learning can be observed and there is more to learning than behavioral changes. For this reason, online learning shifted away from a behaviorist-based approach to a cognitive learning approach. Differing from behaviorist, cognitive learning brings in different skills, including memory, motivation, and thinking about material being presented to them. The cognitive approach focuses on internal processes occurring within the learner, and that the amount of material learned depends on the total capacity of the individual ( Craik & Lockhart, 1972), and the existing knowledge structure of the learner (Ausubel, 1974). A constructivist approach is an effective theory for learning because it stresses that understanding content is a function of knowledge construction and transformation, not solely accumulation of information (Blumenfeld, 1992). More recently, there has been a shift away from the cognitive learning approach to a constructivist theory. This learning theory claims that learners will interpret the information from their own personal realities, and will learn through observation, processing, and interpretation (Cooper, 1993). Even though education theories have shifted over time, online learning can contain principles from all three theories (Ally, 2004).

Electronic learning technologies have increased in popularity because they are convenient, efficient, and affordable (Neal, 2010). Improvements in knowledge have also been shown through electronic learning. There are many other benefits to online learning, including limited travel, convenience, no enrollment barriers, individual

learning style preferences, and the economical aspects. The use of technology has given the idea of distance education a positive vibe, through just-in-time learning – allowing workers to perform training when and where it has to be completed (Larreamendy-Joerns, 2006). Higher education, such as doctoral, masters, and post-doctoral individuals have found online education to be beneficial because classes will not overlap with research projects and content can be viewed at their own convenience (Allen, 2004). The number of students is continually rising. Developing online programs will help meet enrollment demands being placed on educational institutions (Kim, 2006).

Three main variables that can have an impact on the effectiveness of online programs include technology, instructor characteristics, and student characteristics. Technology must be available and user-friendly to have a successful online learning experience. The instructor must be able to get the technology to match with their teaching style or the program will be less effective. Lastly, the student characteristics such as gender and prior experience with technology can have an impact on the effectiveness of online delivery (Volery, 2000). If the learner is more familiar with technology, they will more readily be able to access online curriculum material. Students may also learn more effectively depending on comfort level; introverts may be more hesitant to volunteer in a traditional class but will do so with online delivery. Oppositely, extroverts perform better in a classroom with in-class discussion with peers and the professor (Neuhauser, 2002).

The ability to participate in online education as part of an academic program depends on the institution. Academic institutions including Stanford and Johns Hopkins offer some courses, as well as entire degrees through online education. Other institutions,

including Harvard and the University of California, Berkeley offer some courses online, but those courses are through extension. Some institutions, including Princeton, Yale, and MIT, do not offer any online courses through their degree program (Mayadas, 2009).

To combat food safety issues, food safety educators have to consider classroom barriers, such as negative attitudes, lack of food safety knowledge, and lack of time and awareness of need. Educating about key pre-harvest and post-harvest hazards in an online setting can combat these specific barriers and minimize some of the risks associated with harvesting, storage, and distribution of fresh produce items.

#### Current Food Safety Recommendations

Chemical and physical hazards that occur during pre- and post-harvest produce production can also cause illness to farm workers. Physical hazards include items such as broken glass, wood fragments, and insects in the garden. Chemical concerns include inappropriate application of pesticides, insecticides, herbicides, or rodenticides, which can result in harm or illness to the applicator as well as the consumer, that comes in contact with the contaminant (World Health Organization, 2015).

Most pre-harvest concerns for cross-contamination occur where there is soil with improperly composted manure, contaminated irrigation water, wild or domestic animal presence, and unclean tools and containers used during harvesting (FDA, 1998). These vectors are a concern in school, community, and university gardens because soil and water are essential for plant growth and development. People in the garden must be aware of these hazards, to prevent occurrence during produce production. Additional environmental considerations that can result in contaminated produce during pre-harvest production include prior land usage, adjacent land usage, and contaminated soil (Iowa

State University, 2014). It is important to know the background of the land to ensure that the soil already in the bed has not be tampered with or contain high concentrations of toxic substances. Garden safety risks can be lowered by testing the soil prior to planting and knowing what nearby land has previously been used for. When planting in a school garden, the garden should not be attached to the school, but in a nearby designated area. For university farms, the farm should be developed in an area that had no previous buildings. This will prevent the possibility of having high lead concentration from older paints that could reside in the soil.

The United States Department of Agriculture (USDA) covers many of the pre-harvest hazards in the farm review section of the USDA Good Agricultural Practices (GAP) & Good Handling Practices (GHP) audit program. The pre-harvest farm review section includes subsections on water usage, soil amendments, animals and wildlife, and land use/land use history. Postharvest areas of concern in produce food safety include regulations, postharvest handling and hygiene, packaging and transportation of produce, and chemical application to the field or produce item (USDA, 2011). Other organizations that help give guidance about on-farm food safety include the World Health Organization (WHO), Food and Drug Administration (FDA), the Center for Disease Control and Prevention (CDC), and the National Institute of Health (NIH). The WHO is an agency that is part of the United Nations that focuses on international public health. In Food Science, their focus is to give guidance on nutrition, food security, and healthy eating. The FDA contributes to food safety as an agency within the Department of Health and Human Services, and helps promote public health by setting regulations, as well as supervising food safety of food products. Lastly, The CDC is another

organization that helps with guidance for food safety. Their goal is protect public health and safety through control and prevention of harmful agents, primarily foodborne pathogens. These organizations function under the Department of Health and Human Services, which collaborate to protect the overall health of the public, specifically with food products.

Producers can monitor chemical, physical, and biological hazards in fresh produce by implementing a Hazard Analysis and Critical Control Points (HACCP) system. HACCP is a science-based approach that identifies specific hazards and necessary measures for control and ensures the safety of food. The overall goal of HACCP is to focus on prevention rather than relying on end product testing (FAO, 1997). This program is broken into seven different steps, including: conducting a hazard analysis, identifying critical control points, establishing critical limits, monitoring critical control points, establishing corrective actions, verifications, and recordkeeping practices (University of Nebraska, 2005). Each step of a HACCP program needs to be developed individually, to ensure all food safety risks are throughout the entire process. ALL HACCP principles can be related to both school gardens and university farms, but is not an essential component of a school garden due to the high cost of labor.

If possible, it would be very beneficial to implement a HACCP system into fresh produce operations because produce has no kill step (heating, irradiation) and it has little to no environmental control. HACCP is not a stand-alone food safety program, but has pre-requisite programs that support the overall plan. The main prerequisite programs in pre-harvest produce production include GAPs, Good Manufacturing Practices (GMPs), Standard Operating Procedures (SOPs), and Sanitation Standard Operating Procedures

(SSOPs) (Hurst, 2010). GAPs are a set of guidelines that producers use to reduce the likelihood of microbial or other contamination from occurring on the fresh fruits and vegetables. The main focus of GAPs is to use safe techniques on the farm to fork food chain (Kentucky Department of Agriculture, 2014). GMPs are used to ensure that the product is produced and controlled to meet the standards that are required for the food product (World Health Organization, 2014). SOPs are needed in food production systems to explain how a policy should be implemented. The overall purpose of SOPs is to provide direction and structure for the employee reading the procedures (Iowa State University, 2015). SSOPs are implemented in food processes as written procedures that prevent direct contamination or adulteration of the specific product (USDA FSIS, 2014).

Even though HACCP programs are not required by school, community, or university farms, it would be a very good idea to implement a food safety plan. This plan would include all aspects related to both pre-harvest and postharvest produce production, including manager information, crops grown in the garden, documents records kept, education and training required for those working with the fresh produce, sampling and testing performed to the produce, garden location details, worker facilities and health/hygiene, chemical and water usage, animal control, postharvest handling, and transportation (Penn State University, 2015). The more details present in the plan, the more effective the plan can be. The food safety plan would be well utilized on a university farm, where records can be kept and documented.

### Biosolids & Composting

One way human pathogens enter the fresh produce supply is from inappropriate application of organic manure to the field (ADAS, 2001). Animal manure is known to be

a good source for zoonotic pathogens, including *Escherichia coli* 0157:H7 and *Salmonella* spp. (Himathongkham, 1999).

Foodborne pathogenic bacteria are commonly found in bovine manure. Using manure without prior treatments increases the likelihood of vegetable contamination grown in manure-fertilized soils because viable pathogens may not have been destroyed in its processing (Ingham, 2004). Many foodborne pathogens can survive in manure, making it a potential inocula for contamination (Kudva, 1998). Bacterial counts in manure can contain up to  $10^9$  or  $10^{10}$  CFU/g in fresh feces (Salanitro, 1977).

Pathogens at high population levels are more difficult to control because they can survive in manure for months to years (Jiang, 2001).

Bacteria, viruses, and parasites that are present in the compost can cause harm to humans if it is not properly processed using scientifically valid methods, one of these being compost. To make sure the microbial load is kept to non-detectable levels in the compost, it should be maintained at 55°C for 2 hours or longer (Turner, 2001). When using raw manure, it should be applied at least 120 days prior to harvest. The American Organic Standards mention that uncomposted manure must be applied at least 120 days prior to harvesting fresh products. If 120 days is not feasible, only properly composted manure can be used (Washington State University, 2014). To reduce the likelihood of contamination from untreated manure or compost, compost bins should be kept downhill away from the garden or field. A long-stemmed calibrated thermometer should be used when checking the temperature of the compost to ensure that it maintains a temperature of 130° F for at least five days prior to application on the field. Having a temperature of

130° F or higher will kill *E. coli* 0157:H7 or *Salmonella* that could have been in the compost prior to the heat treatment (Bourquin, 2009).

According to the requirements of the USDA GAP & GHP Program, raw manure can only be used if it is applied to the field 2 weeks before planting and a minimum of 120 day before the crops are harvested. Some documents that are commodity specific and more restrictive do not allow any application of raw manure, or require one-year restriction on its application. For materials that are composted, it is required to have a documented composting procedure that is available for review. If compost has been purchased, there must be documentation from the composter, which lists the specific process used, and test results show potential pathogens have effectively been controlled (USDA, 2011).

Many schools use compost in their garden. Some schools use vermicompost systems, which utilize worms to recycle scraps and organic material, resulting in valuable nutrients for the soil (Cornell University, 1996). Other school gardens, including Cambridge, Massachusetts, have developed guides how to properly recycle lunch waste as a source of compost (City of Cambridge, 2010). The main source used for nitrogen material in the compost include garden waste. Other sources schools use include lunch room waste, classroom waste, production waste, school landscaping, animal waste, and offsite materials. The main source used in schools for the carbon source was also garden waste. However, other sources for carbon include school landscaping waste, animal bedding material, straw and wood shavings, paper material, and materials brought from offsite. With a wide variety of waste products used in school gardens, the garden coordinators and volunteers have to make sure all items are composted to sufficient



temperatures for produce safety when applied to the garden soil. Temperatures of the compost should be documented and recorded to ensure required levels are reached.

Workers must also know where the compost material came from, and how it was handled. By knowing this additional information, the garden managers can set specific safety guidelines to ensure the compost is safely applied to the gardens.

### Soil

Bacteria are found naturally in soil. Types of bacteria may include *Clostridia* and *Bacillus* species, as well as saprophytic bacteria *Listeria*. Soils can become contaminated with pathogens from stool produced from wildlife (McLaughlin, 2002). The rhizosphere has high nutrient content, making bacterial presence abundant. High competition in bacterial populations can allow pathogenic microorganisms to survive in these soil environments (Berg, 2005).

There are a wide range of soil types available, some of which can suppress soilborne pathogens. These soils are termed pathogen- or disease-suppressive soils. They can be either general or specific. Specific soils will attack for only one or a few soil pathogens, where general will help suppress a wider range of microorganisms. Research has shown that specific microbe mechanisms within the soil are the cause of pathogen suppression (Garbeva, 2004). These mechanisms are diverse and allow the soil bacteria to either coexist, or dominate other organisms through cooperation or competition for the same resources (Hibbing, 2010).

In addition to the nutritional health of the soil, pH is an important parameter related to produce food safety to limit growth of microorganisms, including soil-borne pathogens. Most microorganisms prefer minimal acidity present for growth. When acid

levels increase, microbial growth is limited or completely eliminated (Utah State University, 2008). When a raw product has an initial pH value above 4.6 it is considered a low acid food, while high acid foods have a pH value of 4.6 or lower (Cornell University, 2014). Many fruits and vegetables are considered high acid products, but some have a pH higher than 4.6. Regulating the pH of garden soil can also have an impact on heavy metal-plant interaction. Keeping the soil at a neutral pH will help prevent exposure of toxic metals for plant uptake. This is because a majority of the heavy metals in the soil are insoluble or attached to the actual soil and will not be able to reach the edible portions on the fresh produce item (EPA, 2011).

The United States Department of Agriculture (USDA) states that an essential part of garden creation is a soil test. The soil test can show which nutrients are lacking from that soil, determine how much fertilizer is needed, the current pH of the soil, and if any additional lime or other constituents are needed and the concentrations of the component (North Carolina State University and North Carolina A&T State University, 2015). Soil test kits can pinpoint specific parameters that promote microbial growth.

Most local garden centers have inexpensive soil kits available to test soil. Unfortunately, these kits are not reliable. PH measurements could be accurate, but the kits do not inform the user on how much lime must be applied. The only way to receive consistent results is to submit samples to a soil-testing laboratory (North Carolina State University, 2001). Additional parameters that can be determined in a soil sample include micronutrients (iron, zinc, copper, manganese, and boron), heavy metals (lead, nickel, cadmium, chromium), and organic matter composition (University of Maryland, 2014).

The soil in contact with the fresh produce should have as few pathogenic microorganisms as possible. Managing soil is an important aspect of food safety because many human pathogens have the ability to reside in it, which can result in the cross-contamination fresh produce. Based on the bacterial species present, persistence in the soil varies. Viable cells of *Campylobacter* may only survive for 31 days, where *Salmonella* could persist for 332 days (“On-Farm food safety and conservation” – Jo Ann Baumgartner; Wild Farm alliance).

#### Garden Location

Another section of the farm review section in the GAP & GHP Program includes land use and land use history. When processing fresh produce, the operation has to consider adjacent land, as well as if land is on a slope. A risk assessment will help address any potential physical, chemical, and biological hazards that are reasonably likely to cause contamination to the produce. Additional vegetation surrounding the garden will increase presence of rodents and other pests. When planning a garden, choose a location with minimal surrounding vegetation/debris. (Colorado State University, 2014). The garden should be kept away from buildings and tall trees. Most vegetables require 6 to 8 hours of sunlight, which could be hindered with surrounding factors (Delaware Cooperative Extension, 2009). When setting up a school or university garden, should be set aside from any highly traveled locations. Increased presence from outside sources can result in further contamination, or vandalism from external parties. To combat windblown contamination from mobile sources or busy streets, hedges or small fences can be put around the perimeter of the garden (EPA, 2011).

Before selecting the garden location, it is important to plan the details in advance so it will be ready when planting time starts. Some of the main natural factors that affect the garden based on location are soil type, amount of sunlight, other trees or shrubs nearby, and the water supply (University of Illinois, 2014). When planning a produce garden, it is important to choose a location that has good drainage with no standing water. The garden should be kept away from trees and shrubs, because they might compete with produce for water, nutrients, and light (Rutgers University, 2003). The garden should be in a location that is close to a water source, drains well, and receives at least six hours of direct sunlight daily (Bradshaw, 2015). Knowledge of previous land usage can inform on any previous flooding or struggles with growing fresh produce in the area.

Another manmade factors that may have an impact on the garden location and whether or not it is safe to plant include utility lines, signs, fences, and buildings (Clemson University, 2012). If possible, school and university gardens should be located away from buildings or where buildings have previously been. If too close to buildings, the plants may not receive enough sunlight daily. If planting where a building has previously been, chemical hazards, including lead, may be present in the soil from lead paint used on the building (Hornbaker, 2009). Other heavy toxic metals may also be present in the soil. These metals are harmful on both produce quality and human health.

Having previous information on the history of the garden location can show if there is risk of hazards in the soil. Prior to setting up a garden, research should be performed on local laws and regulations (Iowa State University, 2015). Routes of exposure to soil contaminants include ingestion of soil, inhalation of volatiles, absorption through skin, and eating fresh produce that have absorbed the contaminants. It is

important to look at the land itself as well as surrounding lots. Areas of most concern include manufacturing and industrial sites, landfills, junkyards, parking lots, household sites, and former farmland. These locations contribute to soil contamination through chemical leakage, inorganic and organic contaminants that may have leached into the soil, contaminants through vehicle emissions, and potential contaminants from previous fertilizer or pesticide application (Crozier, 2012). Another 4-step solution developed by the USDA can help manage contaminated soil. Initially, soil pH should be increased to a pH of 6.5 or higher. Increasing pH of soil will make the cationic metals less available to plants because they are less soluble in basic conditions. The next step is to drain wet soils. Draining will increase aeration of the soil, allowing metals to oxidize and become less soluble. The third step is to apply phosphate to the soil. Addition of phosphate will further reduce the availability of cationic metals. However, monitor phosphate levels closely. Over application may result in pollution of the water supply. The last step is to carefully select plants based on metals that have contaminated the soil previously. Plants generally transfer metals to their leaves rather than their fruits or seeds. Metal contamination is a higher concern for products like lettuce or spinach (USDA, 2000).

### Water Sources

Significant morbidity and mortality occur worldwide from waterborne diseases (Jokinen, 2010). Quality water sources are becoming more limited, resulting in an overall expected increase from waterborne pathogens (Levantesi, 2011). Three sources of irrigation water used are groundwater/well water, surface water, and human wastewater (Steele, 2004). One main human pathogen of concern that can be waterborne is *Escherichia coli* 0157:H7. To inactivate or kill *E. coli* 0157H7, water can be treated with

chlorine, ultra-violet light, or ozone. Under the Safe Drinking Water Act, the Environmental Protection Agency requires public water systems to be monitored for coliforms and fecal coliforms multiple times per month. Public water systems that serve millions of people may have to take up to 480 samples per month, where smaller systems have to sample at least five times a month (EPA, 2013).

Municipal water may be used as an irrigation source for fresh produce. Municipal water has already been treated, making it safe for human ingestion. Less than 1% of municipal water is used for human consumption, while the rest is used for bathing, watering gardens, cleaning, and cooking (International Bottled Water Association, 2014). To ensure the safety of well water and surface water, tests are taken to prove it is safe for irrigation use. If bacterial counts are high, the water can be chemically treated to reduce the bacterial count (Bourquin, 2009).

Contamination in surface water can come from many sources, including sediment, chemicals, and plant growth. To make surface water acceptable for irrigation, all sediment, chemicals, and plants must be removed prior to application to the produce (University of Massachusetts Amherst, 2009). However, when surface water is used, it is frequently contaminated with human pathogens, which can cause disease when ingested (Schijven, 2011). Runoff on agricultural land can contaminate surface water from fecal material (Avery, 2007).

There are many different irrigation methods used worldwide. These methods include surface, subsurface, sprinkler, and trickle irrigation. Surface irrigation is the oldest type and still encompasses close to 75% of all irrigation. However, the use of surface irrigation can result in serious soil erosion. Erosion will occur because water will

flow where loosened soil is. Subsurface irrigation uses ditches to help control the flow of water. When the season is dry, water will be added and will be equally removed when there is an abundance of water. Subsurface irrigation has minimal problems, but is rarely used because of the high demands that are needed to keep it functioning. Sprinkler irrigation is a newer form of irrigation because pipes, pumps, and a power supply were not available until modern years. Sprinkler irrigation is beneficial because it saves on water, reduce leaching of nitrates and other nutrients, and minimize erosion. However, sprinkler irrigation has high equipment and operational costs and may damage some plants if inappropriately applied. Trickle irrigation (also known as drip irrigation) helps supply water to plants through individual lines. Out of the irrigation methods mentioned, it is the newest and is able to deliver up to 90% of the irrigation water to the root zone of the plant. Erosion is not an issue with trickle irrigation because there is no runoff in the system. Other benefits of trickle irrigation include saving water, functions well in all types of soil, and requires minimal labor after installation. Problems with trickle irrigation include initial costs for cost and individual irrigation lines clogged by sediment (Gezahegne, 2000). There are different microbiological hazards that can occur when choosing which irrigation method to use. The safest microbiological method to use when applying irrigation water is trickle or drip irrigation. This method will minimize the risk of crop contamination because the edible portions of the crop are no being wetted. This method will also reduce plant disease levels while maximizing water efficiency. Overhead irrigation methods pose more of a safety issue, but can be reduced if potable water is used (Rangarajan, 2000). The main difference between agricultural water and potable water is that agricultural water can be used in growing, harvesting, packing, or

holding of produce, where potable water is water that is safe enough to be consumed by humans. Agricultural water is meant to be used in direct contact with fresh produce, but not meant to be physically consumed by the individual. Thus, potable water must be used in product washing and cleaning.

Increased concerns related to food safety are present with urban wastewater because it can include organic and inorganic pollutants and human pathogens. Guidelines have been developed by the World Health Organization (WHO) for the safe use of wastewater in agriculture (Forslund, 2012).

Water should be tested for fecal coliforms. Fecal coliforms are bacteria found in water that can cause illness if ingested. Fecal coliforms do not cause problems for animals or people, but indicate other bacteria that can cause disease and are present, such as typhoid, hepatitis A, cholera, and dysentery (EPA, 2008). There is zero tolerance if coliforms and *E. coli* are found in drinking water. Results can be reported as absent, 0 colony forming units per 100 milliliters, less than 1 colony forming unit per 100 milliliters, number of colony forming units per parts per million, or non-detected (New Brunswick, 2015).

To combat the contamination risks associated with irrigation water, the FDA developed a guide on Good Agricultural Practices to lower the likelihood of produce contamination occurring. In October 1998, the FDA released the “Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables.” The guide recognizes the importance of water safety in pre-harvest application to ensure the safety of fresh produce.



## Animals

Another source of potential contamination for fresh produce is wild and domestic animals. Contamination risk is high when fresh produce is in the field. Both domestic and wild animals can come in contact with the fresh produce and contaminate the product early (Lynch, 2008). Animals that are most commonly associated with fecal contamination include deer, beavers, muskrats, rodents, gulls, and geese. Additional wildlife that may be present include coyotes, foxes, rabbits, and donkeys. These animals introduce microorganisms into soil, which can later enter the water supply by runoff (EPA, 2001).

If animals are needed in the processing operation, a risk assessment will be included and documented in the SOPs. GAP & GHP Program realizes that animals can never be completely removed from crop production areas. However, measures need to be put in place to limit overall access to the produce field. Local, state, and federal regulations must be considered when developing strategies to limit animal presence in or around the produce production area.

Contaminated feed, ineffective cleaning and disinfection on farms are a few ways that the animals contaminate the fresh produce (EFSA, 2010). Livestock, wildlife, and pets can deliver pathogenic bacteria to surface water bodies (Knox, 2007).

To reduce problem wildlife in the garden, it is important to build in an integrated pest management (IPM) plan for the specific garden. Initially, it is important to scout the garden to check for any physical appearance of pests, and continue scouting at least once per week after planting crops. By looking at the crop and finding damage, it may be possible to determine what the pest is and what management strategy is available for the

crop. Based on the pest, there are different types of control measures. These include mechanical control, sanitary control, biological control, chemical control, and integrated control. Mechanical control is setting up barriers that protect the crop, including row covers or traps to control the pests. Sanitary control occurs when overripe products are removed to prevent pests from moving from plant to plant. Pests can also be controlled by placing biological control measures in place. Biological control can occur by having bacterium or fungi that can attack or fight off pests in the right environment. When pests reach a certain threshold level, the last resort would be to use an insecticide to control the pest. Lastly, integrated control is the use of many different control types to control the pest from the garden (The Ohio State University, 2007).

When considering potential pests, it is important to focus on the specific pest. Knowing the species will help identify its specific habits, and what can be done to develop the best control strategies. Keeping garbage in a secure container away from the garden will make it difficult for pests to open them, and will reduce wildlife presence in the garden (National Pesticide Information Center, 2014). Another way to keep unwanted wildlife out of the garden is to create barriers that make it more difficult for them to reach the plants. Building raised beds is an acceptable way to keep some pests out. Beds should be 18 inches high, and secured with  $\frac{1}{4}$  " mesh around the bottom to prevent burrowing animals from reaching the produce (West Virginia University, 2012). Physical barriers can also reduce incidences of vandalism, trespassing, or foot traffic through the garden (University of Georgia, 2012). If physical barriers are not feasible, repellents are available commercially for specific pest types (Utah State University, 2005).

### Chemical Hazards

Chemical hazards are divided into two categories: prohibited or deleterious substances. It is the processors responsibility to ensure that none of the prohibited chemicals are present. Unavoidable poisonous or deleterious chemicals have tolerance levels set by the FDA, in the event of exposure to the chemical (University of Nebraska, 2005).

Metals can be a chemical hazard in pre-harvest production, having been introduced into the garden from previous farming practices. Heavy toxic metals that are of most concern and can be found in farm soil include arsenic, cadmium, chromium, lead, nickel, and mercury (Oregon State University, 2010). Populations are most commonly exposed to arsenic via food or drinking water intake. If ingested, arsenic can result in gastrointestinal symptoms, disturbances in cardiovascular and central nervous systems, and eventually result in death. Exposure to cadmium may result in kidney damage, and inhalation of cadmium fumes may be life threatening. Symptoms from acute lead poisoning include headache, irritability, abdominal pain, and various nervous system symptoms. Long time exposure to lead may result in memory deterioration, prolonged reaction time, and lower the rate of understanding. Lastly, acute mercury damage could result in lung damage. Chronic poisoning may result in symptoms of tremor, personality change, restlessness, anxiety, and depression (Järup, 2003). Contamination from these toxic metals depends on soil, water, the environment in relation to the garden or farm site, and the use or absence of pesticides (Koumolou, 2012).

Persistent toxic substances (PTSs) are trace metals that are typical components that result in chemical contamination (Nraigu, 1988). Some of the main sources of PTSs

and POPs include industrial wastes, traffic emissions, and other wastes from municipal activities (Wong, 2006).

Surface water and groundwater can become contaminated by heavy metals, resulting in the deterioration of water quality (Krishna, 2009). Cadmium, chromium, manganese, and lead can all be found in water and are highly toxic if ingested at high concentrations (Ouyang, 2002). To help minimize chemical contaminants in water, limits are set, known as maximum contaminant levels (MCL), which set a quantitative amount on how much of the contaminant can be present in the water supply. The MCL is established by the U.S. Environmental protection agency. The MCL is determined based on whether the chemical is believed to cause cancer or not. The MCL for chemicals believed to cause cancer is set to zero, meaning zero tolerance for the contaminant in the water supply (Kamrin, 1997).

Lead is one of the main hazardous chemicals found in field soil, dust, and paint (Rabinowitz, 1984). It has been shown to have adverse health effects on children. Lead is typically found in lower levels, but increased pollution can increase lead to harmful concentration levels. Locations with the highest risk of lead contamination include buildings constructed before 1978, where lead could have leached from the paint and into the soil (California Department of Education, 2014). Lead is a main chemical concern because it affects the brain and nervous system, with increased vulnerability in children. Research has also shown a relationship between increased lead in the blood with reduced intellectual development (Schwartz, 1994).

Some common pests that can be found in or around the garden include weeds, hornworms, aphids, and grubs (EPA, 2005). However, pesticides, including herbicides,

insecticides, and fungicides, can be detrimental in pre-harvest production if applied incorrectly. They can cause injury to plants, impair human health, and cause pollution to soil, air, and water (University of California Agriculture & Natural Resources, 2014). Chemical contamination can result from the pesticide solution itself. The solution composition could stimulate or inhibit microbial growth (Ng, 2005). To reduce pests in the garden, healthy seeds and seedlings should be chosen that can resist disease better. By alternating rows of different plants, pests that prefer a specific type of produce item will not be able to spread to the neighboring rows. It is important not to plant the same crop in the same location every year. If pests have the ability to survive through the winter they will be able to infect crops at the beginning of the next growing season. Lastly, it is important to make sure the garden has good drainage (EPA, 2005).

Another way to control pesticide problems and reduce the risk of chemical contamination is to make sure the person applying the pesticide is a licensed applicator, and that they read the label prior to application. Currently at Iowa State University, there is a Pest management and the environment program (PME) that serves to educate on safe use of pesticides throughout Iowa. This program is responsible for pesticide applicator training and works in cooperation with the Iowa Department of Agriculture and Land Stewardship. The ISU PME is also involved with integrated pest management, worker protection, water quality, and agricultural health. (Iowa State University, 2014).

To protect the handler, always wear impermeable gloves and long shirts. When finished, remove gloves and wash hands immediately after application. Lastly, when applying pesticides to produce, remove children, toys, and pets from the area being

sprayed. Keep them out until the pesticide has dried, or follow the recommendation on the label (EPA, 2012).

### Physical Hazards

Physical hazards are a type of hazards from foreign objects that have the capability of injuring the consumer or farm worker upon contact. These include metals, glass, wood, hard plastics, and stones (Harris, 2010). There are many different ways physical hazards can be introduced into the garden and processing areas. Sources include raw materials, badly maintained facilities and equipment, improper production procedures, and poor employee practices (Shaw, 2012). There are three different classifications of physical hazards, which are separated on the likelihood of their presence. Class 1 physical hazards are of high likelihood, where there is little or no control measure established. Class 2 physical hazards have a moderate likelihood of causing harm, but there is still some control established. Class 3 physical hazards are of low risk where control measures have been established (Anonymous, 2014). According to the Compliance Policy Guide (CPG) in section 555.425, ready-to-eat food is considered adulterated if it contains hard or sharp foreign objects between the sizes of 7mm to 25 mm in length (Herman, 2015).

To prevent physical hazards from occurring in the garden, employees should perform routine inspections of the field. Frequent monitoring will allow employees to find the harmful physical pieces and remove them as needed. Waste or trash receptacles should be close to the field so proper and efficient disposal can occur.

To prevent physical harm from occurring, it is important to wear appropriate clothing while in or around the garden. If available, wear long shirts, sturdy shoes, and

long pants to prevent physical injury from occurring. It is also important to wear gloves to reduce the risk of skin irritation or cuts (CDC, 2014).

### Produce Storage

Overall shelf-life of produce depends on the specific produce type, but can range from between 7-20 days when stored at the recommended temperatures (Watada, 1998). Once past the desired storage time, spoilage microorganisms start to form, including *Pseudomonas spp.*, Lactic acid bacteria, and various forms of yeasts. These microbes form metabolites (ethanol, lactic acid and ethyl acetate), which increase the overall respiration and spoilage of the fresh produce (Guerzoni, 1996). Increasing the shelf-life length of fresh produce can allow for significant increase in pathogen populations, increasing risk for the consumer (Francis, 2001). It is crucial to monitor the shelf life of all produce items when working on a school or university farm.

Different packaging methods have been used in recent years to help increase the shelf-life of fresh produce. Initially, it is advised to rinse the produce after harvest to remove any potential pesticide residue, debris from plants, or other contamination risks. Once completed, it is advised to dip the harvested produce in chlorinated water to reduce the microbial load and delay the physical decay of the produce tissues (Soliva-Fortuny, 2003).

Generally, low oxygen and/or high carbon dioxide concentrations will help slow the respiration rate of fresh produce, which reduces the deterioration rate of the product (Babic, 1996). Therefore, fresh produce has been packaged in Modified atmosphere packaging (MAP), or a controlled atmosphere (CA) in recent years to delay the effects of spoilage microorganisms on fresh produce. This controlled atmosphere has high levels of

carbon dioxide present in the packaging, modifying the total amount of carboxyl reactions from occurring. These reactions will have an impact on intermediate spoilage metabolites that spoil fresh produce through competitive inhibition with ethylene (Allende, 2004).

The type of packaging used can influence pathogenic bacterial growth. Currently, modified atmosphere packaging (MAP) is largely used in minimally processed, ready-to-eat produce items. From both a safety and quality aspect, MAP should contain 1-5% oxygen in its packaging (Sandhya, 2010). By limiting the oxygen availability, decreased growth in aerobic pathogens will occur. University farms could implement this method of packaging and other techniques as a form of hurdle technology to prevent pathogen growth on fresh produce items.

To reduce the risk of premature spoilage and potential pathogen growth, it is recommended to process produce immediately after harvest. Shelf-life is significantly reduced following a storage time prior to processing (Witkowska, 2013). It is also advised to keep freshly harvested produce in the correct temperature conditions. Significantly higher bacterial counts were observed when vegetables were stored at 10C as opposed to 4C (Odumeru, 1997). In addition to reducing spoilage microbes, it is important to store fresh produce at correct temperatures to minimize pathogenic bacterial presence. The United States Food and Drug Administration Food Code now requires Ready-to-eat (RTE) fruits and vegetables be stored at 5C or lower to minimize growth of foodborne pathogens (Zeng, 2014).

Shelf life varies between produce items when refrigerating harvested fresh produce. Melons shelf-life may be as low as one week, where pear shelf-life can last up



to three months. If holding fresh produce longer than the acceptable shelf-life, pathogen growth on fresh produce can occur. The survival of harmful microbes can be influenced by the organism causing the illness, the specific produce item, and the environment in which the produce is stored. Some microbes will have a more favorable growth on specific produce items. Improper storage temperature will allow microbes to grow at a higher rate, increasing the risk of microbial contamination (FDA, 2013).

#### Transportation of Fresh Produce

One of the main ways transportation can affect fresh produce is inappropriate temperature during transport. The overall time the fresh produce spends on the transportation vehicles is the most significant factor, which may result in problems in food distribution (Osvald, 2008). Total plate count could increase due to elevated temperature, agitation, and impact during transportation (Senter, 1984). There are both benefits and detriments when considering flight versus ground operations. When transporting by truck, the temperature can be maintained within the appropriate limits for acceptability, but the total length of time for travel reduces the time the fresh produce is acceptable for market. Transportation by flight allows food to arrive to the destination early, but the temperature fluctuates more frequently than by ground (Brecht, 2003). In school and university farm settings, fresh produce may be transported by non-temperature controlled portable bins.

Another way produce can be affected during transport is through physical vibrations or interactions with other fresh produce or with the vehicle itself. Two specific factors that have been found in transportation that affect the bruising of fruits are the magnitude of the force applied and how often the force is repeated (O'Brien, 1963). The

highest acceleration levels have been observed in bottom tier containers in transportation vehicles. Strapping produce and vertically storing during produce has shown to cause more overall damage. A preferred alternative is to use sideways loading to reduce the total damage on the fresh produce loads (Peleg, 1986). When transporting fruits and vegetables, there is a trade off between the cost of protection and prevention of bruising and the cost of fruit and vegetables losses. If high damage is seen, an increase in protection can occur by changing to packaging that has more energy absorbing characteristics. However, if minimal damage is observed, it may be more beneficial to switch to cheaper forms of transportation and packaging (Schoorl, 1982).

If fresh produce is not transported appropriately, pathogen survival and growth can be introduced, resulting in cross-contamination of the product. While transporting, it is important to make sure the produce is wrapped, covered, or protected. The material the produce is being transported should not have hard to reach areas, and should be able to be cleaned and sanitized after each use. Plastic bins would be ideal, but materials such as cardboard boxes or wooden crates should be avoided. These types of materials can break while being transported, and introduce physical hazards to the fresh produce. Additionally, porous containers should be avoided during transportation to reduce microbial buildup or chances of bacterial biofilm formation. Using smooth containers will allow the workers to remove any potential microbes in the storage container.

When transporting, produce items should also be kept cold. Putting fresh produce on ice or in a refrigerated compartment will help slow the growth of microorganisms, reduce the respiration rate of the produce item, and will extend the shelf-life of the product. To further reduce the chances of cross-contamination from occurring, it is

necessary to make sure the vehicles used to transport the produce are clean (The Ohio State University, 2007). Prior to transportation, vehicles should be visually inspected and sanitized to minimize cross-contamination to the produce. Records of transportation temperature, and logs for sanitation should be kept to ensure the safety of the produce items. Vehicles that are used to transport fruits and vegetables should not be used to transport other items, such as animals, chemicals, or compostable materials. Increased chance of chemical or microbial contamination is much higher if vehicles are used for other non-produce related items (The Ohio State University, 2007).

### Personal Hygiene

Some food handlers working in school gardens and university farms are currently unaware of the basic steps behind proper hand washing. When implementing proper employee practices, knowledge barriers and psychological barriers must be considered. These include lack of awareness and lack of motivation (Garayoa, 2011). Personal hygiene and environmental sanitation are two key factors of foodborne disease. Mukhopadhyay, et al. (2012) performed a study in Kolkata that found that many food handlers disregard illnesses symptoms, such as diarrhea, sore throat, and skin infection, and continue working as normal. Hand hygiene is crucial in reducing contamination of food to minimize biological risks associated with foodborne illness. Proper training is very important for all employees, and all training related to hygienic aspects should be required and confirmed prior to handling food products (Lehto et al., 2010).

To reduce the risk of spreading foodborne infections and illness, food handlers must wash their hands at the appropriate times, and in the correct way. Food handlers should wash hands at any point during food preparation, eating food, or after treating a

cut or wound. Hand should also be washed after using the restroom, coughing or sneezing, touching animals or animal waste, and touching garbage. When hand washing, they should initially wet their hands with potable running water and apply soap. After soap is applied, their hands should be lathered. This includes the back of hands, in between fingers, and under fingernails. Hands should be slathered with soap for 10-15 seconds. Hands should then be rinsed under clean, running water, and dried using disposable towels or air dried (CDC, 2013).

When suffering from illness, food handlers should inform their supervisor that they are feeling unwell. They should not come to work if they are vomiting or have diarrhea. Food handlers need to stay away until symptoms have ceased for 48 hours (NHS, 2014). Informational and reminder forms should be placed around the garden entrance and near the restroom facilities. This information will help students, volunteers, and workers be more familiar with why personal hygiene is important, the different vectors that can assist in cross-contamination, and when they should not come in direct contact with the produce. Signage placed outside of the restroom can be more related to proper handwashing practices, pathogens of concern associated with poor personal hygiene, and important cross-contamination prevention strategies. Information forms in the field can go into more details on how produce should be safely harvested, where it should be placed, and how it should be stored to prevent cross-contamination from occurring.

It is important for workers to remember that clothes and shoes can result in cross-contamination. Also, when workers are handling compost or manure, shoes must be changed prior to entering the vegetable garden (University of Maine, 2015). Following

good employee practices with proper personal hygiene will significantly reduce the chances of a foodborne illness outbreak from occurring.

### Current Regulations

To help reduce some of the current food safety risks associated with fresh produce, the government is working on implementing regulations to protect people that consume them. The major regulations associated with fresh produce include the Food Safety Modernization Act (FSMA), the Harmonization Initiative, and United States Department of Agriculture (USDA) Good Agricultural Practices (GAPs) and Good Handling Practices (GHPs) manual.

Laws and regulations have been proposed to ensure quality and safety of food commodity groups. Physical, chemical, and biological hazards have the chance of enter food systems, eventually harming employees or consumers. To protect people from hazards, federal laws focus on the scope of risk to protect consumers from contaminated produce items.

### USDA GAP Audits

The Food and Drug Administration (FDA) released a document, “*Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables*,” which contained the general guidelines for reducing risk in fresh produce by microbial contamination in October 1998. Many requests were made by the fruit and vegetable industry to develop and audit based program for verification of the document. In January 2002, the United States Department of Agriculture (USDA) Agriculture Marketing Service (AMS) formally implemented a Good Agricultural Practices (GAP) and Good

Handling Practices (GHP) audit verification program. The audit form can help serve as a guide to hazards that may occur in school gardens or on university farms.

Performing an audit will not guarantee the product will be free from microbial contamination, but helps verify the individual is taking positive measures to reduce risks of contamination. Reviewing the criteria of this guide can help eliminate food safety risks in school and university gardens throughout pre-harvest and postharvest production.

The USDA GAP audit form helps break down each aspect and area of where hazards can occur. They include a farm review that goes into water usage, soil amendments, animals and wildlife, and land use and land use history; field harvesting & field packing activities, which include areas of field sanitation, harvesting containers & equipment, transportation of produce, emergency clean up procedures, and monitoring the house packing facility. Procedures can be verified by the use of checklists provided in the USDA GAP audit form.

#### Harmonization Initiative

In 2004, the Institute of Food Technologists (IFT) joined with the European Federation of Food Science and Technology (EFFoST) to develop the Global Harmonization Initiative (GHI). In 2009, a plan was endorsed to result in harmonization of Good Agricultural Practices (GAP) standards by the United Fresh Food Safety and Technology Council. The main purpose of the initiative was to focus on food safety, rather than passing audits. The overall goal of the harmonization initiative is, “one audit by any credible third party, acceptable to all buyers.”

The initiative includes produce growers, shippers, buyers, government agencies, audit organizations, and other stakeholders. A checklist was generated for pre-harvest and

postharvest operations that included food safety GAPs standards and audits. The checklist was then modified for different regions and farm sizes, and made applicable to all fresh produce commodities.

#### Food Safety Modernization Act (FSMA)

President Obama signed into law the Food Safety Modernization Act (FSMA) on January 4, 2011. FSMA is shifting its food safety focus from reaction and response to prevention. Changing the focus will allow preventative measures to be systematically constructed and incorporated into all parts of the food system (Taylor, 2011). FSMA development has considered small, medium, and large farms.

With the recent update of the FSMA, improved prevention, surveillance, and response grant the FDA greater powers to safeguard imported food (Stewart, 2011). The FSMA now includes ways for the FDA to respond to contamination problems. The FDA has been given mandatory recall authority. Previously, the FDA could not require a recall, but firms would generally follow recall procedures when requested by the FDA. Now, the FDA will develop standards and information displayed on the Internet and in grocery stores (USDA, 2011). The standards focus on agricultural water, biological soil of animal origin, proper hygiene, wildlife in the growing area, and equipment used.

FSMA holds the industry accountable to performing inspections to ensure produce is being processed safely. Imported food will meet US standards through the use of new tools developed by the FDA. Preventative controls must be verified by importers to ensure safety of their foreign suppliers. Third party auditors can be appointed by the FDA to certify that the produce from the imported food facilities is compliant with the

U.S. food safety standards. If food has refused U.S. inspection, the FDA now has the authority to refuse its entry into the United States.

Science-based standards are proposed by the FDA focusing on the growing, harvesting, packing, and holding of produce on the farm. FSMA is being incorporated into all types of food. However in produce, FSMA identifies microbial contamination routes to fresh produce, including agricultural water, biological soil amendments of animal origin, health and hygiene, domestic and wild animals, equipment and tools, and training.

When university farms plan on selling their remaining crops to retail, it will be necessary for them to have appropriate standards and records in place to minimize the potential hazards that FSMA is trying to address.



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## CHAPTER 3:

### DEVELOPMENT OF AN ONLINE FOOD SAFETY CURRICULUM FOR EMPLOYEES OF UNIVERSITY FARMS AND STUDENTS IN SCHOOL GARDENS

#### Introduction

With an increase in produce consumption comes food safety concern because the majority of fruits and vegetables are consumed raw with no intervention strategies to kill harmful pathogens that may be present. Between the years 1998-2008, 46% of total reported foodborne illnesses in the United States were attributed to fresh produce and nuts, of which 22% of these were due to leafy vegetables (Painter et al., 2013).

University farms are important for research purposes and also provide fresh produce to communities. While produce grown at university farms has a primary research purpose, remaining produce may be sold directly to markets or consumers. Researchers who oversee production farms may not have knowledge about the importance of safe food handling during the growing and harvesting of crops.

It is estimated that there are close to 24 million students working in school gardens in the U.S., many affiliated with farm to school programs that are often utilized for teaching subjects such as math and science (USDA FNS, 2014). Produce grown in these gardens needs to be safe because children are at a higher risk of becoming ill from a foodborne disease.

Educators have been integrating the Internet as a tool for teaching and learning for more than a decade (Barak & Dori, 2005). Online learning is expected to increase in the future due to many benefits, including reduced costs in travel and time, convenience,

efficient training of individuals, shorter training programs, ease of availability, and reaching a wide range of learning styles for participants (Bartley, 2004; Evans & Haase, 2001; Volery, 2000).

Few online video based trainings are available for school and university gardens to incorporate into school gardens and university farms. The Oregon Department of Education, Denver Urban Gardens, and North Carolina State University have developed online materials for school garden food safety training that have incorporated subject materials into the program (Oregon Department of Education, 2013, Denver Urban Gardens, 2007, Growing Gardeners, 2015).

In our work, the online training modules were developed to teach students food safety practices in gardens, with a trained instructor/facilitator present to guide viewers, reinforcing concepts as needed throughout. Activities and module development for our study were focused around the cognitive theory, which utilizes memory, motivation, and skill development ( Craik & Lockhart, 1972). Our online curriculum differs from other resources available by having an inclusive program, with supplemental trainer material, available from a single webpage.

### Methodology

Module content was developed in chronological order of garden crop production, with planting to distribution of fresh produce. Training videos were divided into four school garden or five university farm sections; hazard presence; hazard prevention; good agricultural practices; current research findings. The elementary module was divided into introduction, pre-harvest best practices prevention, post-harvest best practices and prevention, and good handling practices and cross-contamination sections. The

university module was divided into introduction and importance of training, pre-harvest and best practices prevention, post-harvest best practices and prevention, a good handling practices and proper personal hygiene, and a current regulations in fresh produce sections.

Video footage and images were gathered from the Brenton Center at Iowa State University and extension specialists around the state of Iowa. Examples were used throughout the modules to increase understanding for the viewer. Figures 6 and 7 are screen shots of the website in its current state. The website was developed and made available on the Iowa State University College of Agriculture and Life Sciences domain. Website information includes online training videos (divided by section), a summary of training, contact information, additional activities, downloadable videos, online quizzes, and the instructor manual. Postcards were developed using a graphic artist and printing company to display this website to schools and university participants.

Module scripts were developed and formatted to align with overall organization. Scripts were written to ensure that untrained or inexperienced participants could understand module content. Minimal scientific language was used in the elementary module, with curriculum expectations reviewed to ensure scientific terms and reading levels were appropriate for the audience. A fifth grade reading level was selected for the elementary module. The university module was developed for lay viewers (high school level or older) that had been exposed to science previously, and would be more familiar with technical terms. A twelfth grade reading level was selected for the university module to relate to high school seniors or university garden workers. Language was user-friendly, allowing for a lay audience to understand the content presented. The Flesch-Kincaid



grade level test was used to on modules to verify module language was appropriate for each audience. The Flesch-Kincaid grade level test evaluates the number of words and the number of syllables used per sentence. By focusing on these parameters we could estimate the complexity of the script and then relate with targeted grade levels (K-12) in the United States (University of South Florida, 2015).

Ten point multiple-choice quizzes were developed and incorporated into training after each section to test for knowledge retention. Quiz questions were reviewed by the expert steering committee to verify content was relevant and appropriate for each audience. Quizzes were pilot tested with students (n= 43) and farm workers (n= 25) before and after viewing the online modules and completing the additional activities provided on the online website. Answer keys were provided for instructors/facilitators with rationale for correct answer. All Information was incorporated into an instructor manual in chronological order.

Additional activities were developed to test for knowledge retention. These include two case studies and an interactive graphic. Figures 1 and 2 show the case studies used in the elementary module, while figures 3 and 4 are the case study examples used in the university module. Figure 5 is the interactive graphic developed in which students identify garden hazards and determine hazard preventative measures. All additional activities were developed for participants to identify hazards and hazard prevention techniques.

Instructor manuals were developed to provide additional resources for instructors. Educational requirements for one state were included and gathered from the Iowa Department of Education guidelines, available at <http://www.educateiowa.gov>. The

online resource provided our team with the state of Iowa educational requirements of in math and science curriculums for each grade level. Standards for each grade level helped our team focus on depth of knowledge and ways to relate training programs to class curriculums. Instructor manuals were organized into different sections, including vocabulary terms used, required tools, benefits, outcomes, quizzes and additional activity answer keys, scripts, risk management, and a comprehensive list of additional resources. The manual was developed for instructors/facilitators to increase confidence and convenience, provide supplemental support to the facilitator prior to performing the training, and to conveniently make available other resources.

Prior to posting, module content was reviewed by the expert steering committee. The committee was comprised of six individuals who work directly with school or community gardens, or university farms. Committee members had a wide range of expertise, including food safety specialists, a horticulture expert, and a non-profit school employee. Meetings were held three times over a one year period to help with development, organization, and additional modification of the modules. Oral, written, and survey feedback was taken from the committee during module development; modifications and additions were incorporated into sections of both training modules.

To further improve modules to meet the needs of school gardens and university farm workers, surveys were developed to receive feedback from instructors and the expert steering committee members after performing the web-based training. Table 3.1 show the questions asked for the elementary module, while table 3.2 show questions asked for the university module. Questions asked focused on clarity, visual appeal,

format, and changes suggested in the modules. Survey questions were developed using the Qualtrics System, using the Likert Scale and open-ended questions.

### Results and Discussion

The online curriculums for school gardens and university farms were developed to reduce the risk of contaminated produce items from reaching individuals that are more susceptible to foodborne illness, to increase awareness in farm workers of the foodborne risks associated with fresh produce. It is vital for farm workers to understand produce must be grown and harvested using Good Agricultural Practices and Good Handling Practices to reduce foodborne illness risk with in fresh produce sold to the local community. A majority of fresh produce developed in school gardens will be served in school lunches. Many of these students are younger in age, without fully developed immune systems. University farm produce that is not used for research is sent out for sale in the community. These produce items may reach young, elderly, or immune compromised individuals. If contaminated produce reaches these susceptible individuals, there is a greater chance that foodborne illness or death can occur.

Our training programs have helped reinforce the importance of instructor knowledge prior to performing distance education in food safety courses. Beyond educating school children and university farm workers, additional content was developed to increase knowledge and self-efficacy for instructors and facilitators of online training. Liceaga (2014) performed a study to evaluate high school educator knowledge and self-efficacy increases in an online food science course. After completing the online course, significant knowledge were observed and instructors had increased confidence when teaching material to their students. Our developed curriculum focuses on increasing

confidence and knowledge to the facilitator prior to performing training through the use of instructor manuals as well. Survey results found that instructors felt more confident in performing the online training programs after viewing the online modules and supplemental information.

We found that our online curriculums were beneficial to both populations tested. Instructors found the interactive website easily manageable and a helpful resource in accessing additional activities. The additional activities including the case studies, interactive graphic, downloadable module videos, and supplemental instructor guide are available below the summary statements. Neal Jr., et al. (2011) developed an evaluation tool for online food safety training programs. They found online programs beneficial for employees because they can work at their own pace, meet the needs of full-time individuals, and continue education for current employees. Figures 1 and 2 are case studies that were developed for the younger participants in school gardens, where figures 3 and 4 were created for older learners working on university farms. Figure 5 is the developed interactive graphic for younger students to identify garden hazards. Figure 6 and figure 7 provide the layout of our online website. Modules are available in top middle portion of the webpage and each individual section is available in the upper right corner of each webpage. Below the module includes a summary of the importance of training and what can be gained. Overall, participants and instructors found the supplemental information beneficial; the basic website layout was easy to maneuver and contained a fair amount of additional information.

Feedback for module improvement was gathered through surveys from both elementary school teachers in Iowa and university instructors. Survey return rate was

81.8%, collecting 9 out of the initial 11 requested surveys. Instructors identified areas of improvement for modules and activities. It is essential to ensure the instructor is knowledgeable prior to implementing training with students. Table 1 and table 2 include survey questions asked to instructors after viewing the developed material and recommended changes to the modules. Suggestions for improvement included better pictures for increased clarity, updating difficulty of quizzes, and images tailored toward youth and adults. Song (2004) found the design of the course, time management, and overall comfort with online technology will increase success in online education. After receiving feedback and making changes for based on each audience preference, our online training material will increase comfort for both age groups, making each training program more effective. Instructors identified specific images and video in both modules that did not fully relate to the viewing audience. To meet the need of each demographic, additional video footage and images were captured to allow for a more fulfilling learning experience. The use of visual aids has been shown as a potential method to increase comprehension for risks. Our research found similar results in that the supplemental material was found beneficial for both instructors and students. Garcia-Retamero & Galesic (2010) discovered that the use of visual aids resulted in large improvements when compared to raw information when provided to audiences. Updating and improving the visual aids in the online training will further engage the learner, resulting in a more successful learning experience. Based on instructor feedback, scripts were further modified to include more details, activities were reworked, and new quiz questions were developed.

Limitations were measured while filming and with development of the modules. Images and video footage could only be captured during the produce growing seasons, making it a challenge to capture every desired example for both modules. Language use was another barrier noted while developing key portions of the modules. Because modules were developed for a wide range of learning levels, participants on either ends of the spectrum may have found language either too simple or too complex.

### Conclusion

This project was successful in developing a complete food safety training curriculum for elementary, community and university farms. Module development and instructor feedback has allowed for:

- 1) Distribution throughout the state of Iowa, including FFA and 4-H educators, state agencies that are involved in Farm to School programs, school district and child nutrition program administrators, and higher education farm managers.
- 2) Updating the modules and additional activities to meet the desired needs of instructors and module participants.
- 3) Education in local schools, community gardens, community colleges, and universities on safe practices associated with production of fresh produce. This project will be shared with food safety extension specialists that are actively engaging in farm outreach efforts.

Scripts are being translated into Spanish to reach a wider population. This project has resulted in the development of specialized food safety trainings that will change behaviors of produce growers in school gardens and university farms. Implementing effective training in schools and universities will help mitigate foodborne illness risks.

Knowledge is a precursor to behavioral changes; implementing training will give produce handlers sufficient knowledge to reduce risk while in direct contact with fresh produce.

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**Table 3.1. Survey questions for elementary module instructors.**

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
1. The volume of the speaker was easily understandable.					
2. The speed of the speaker improved my learning.					
3. The speaker's pronunciation was clear throughout the video.					
4. The title of the video represented what the video was about					
5. The colors used in the video made it more interesting and engaging.					
6. The video included an interesting introduction on the purpose of the video.					
7. The video allowed time for me to clearly understand the concepts.					
8. The video appeared biased (one-sided, critical of opposing views, etc.).					
9. The topics covered were appropriate for the age of the audience.					
10. The video included a detailed summary of information covered.					
11. I could clearly understand the vocabulary used in the module.					
12. The images used were related to the specific food safety topic.					
13. Overall, the images were visually appealing.					
14. The graphics used helped me understand the material.					
15. The length of the module was acceptable.					

**Table 3.1. Continued**

16. The order of the material presented helped me increase my understanding.					
17. The hands on activities contributed to my understanding.					
18. The video gave an understanding on physical, chemical, and biological hazards.					
19. The length of the quizzes was appropriate for the material in the module.					
20. The format of the quizzes was beneficial to my learning.					
21. The difficulty of the quizzes was fairly based on the module content.					
22. The online website was easy to navigate.					
23. I have learned how to reduce the chances of hazards from occurring.					
24. The additional activities helped me understand where hazards can occur.					
25. This module taught me why it's important to be safe when in the garden.					
26. The information in the resource guide was helpful.					

27. Which images did you find most beneficial from the module?

28. Which images did you think were least effective?

29. Are there any images that can be added to help your understanding of the material?

30. What language (if any) was too complicated?

31. Were there any words used that you did not understand the meaning of?

32. Were there any topics in the module that you could not understand?

33. Are there any sections in the module in which more video footage would help you understand the concepts more clearly?
34. Did you like the setup of the online webpage?
35. Did a summary of the video appear on the web page?
36. How can the webpage be improved to be more user-friendly?
37. Did you understand the material from all of the sections?
38. Should any of the concepts be further explained?
39. Which sections need improvement?

**Table 3.2. Survey questions for University module facilitators.**

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
1. The narrator's pace allowed me to understand the module content.					
2. The narrator's volume allowed me to hear the module content.					
3. The narrator's pronunciation was clear throughout the module.					
4. I could understand the vocabulary used throughout the module.					
5. The topics covered were appropriate for the age of the audience.					
6. Overall, the module was colorful and visually appealing.					
7. The title of the module represented what the module was about.					
8. The module began with an interesting introduction explaining its purpose.					
9. The module appeared biased (one-sided, critical of opposing views, etc.).					
10. The module allowed time for you to think about what was being said.					
11. The images and graphics were appropriate for the module content.					
12. The difficulty of the quizzes tested my knowledge.					

**Table 3.2. Continued**

13. The length of the quizzes were appropriate for each section of the module.					
14. The quiz format was appropriate based on the module content.					
15. The module gave understanding on physical, chemical, and biological hazards.					
16. I have learned how to maintain overall personal hygiene.					
17. I have learned the steps on how to properly wash my hands.					
18. I know the symptoms for when I should call in sick for work.					
19. I understand the importance of the different regulations in produce safety.					
20. I can appropriately keep records when harvesting produce.					
21. I understand what HACCP is, and all of the subsections that go into it.					
22. I have learned how to store produce items to maintain safety and quality.					
23. The module was organized and had a good flow from topic to topic.					
24. The website was easy to follow and information was easily attainable.					

**Table 3.2. Continued**

25. The hands on activities in the module contributed to my overall learning.					
26. The additional activities on the website provided good real world examples.					
27. The website references provided me with more information on each section.					
28. The length of the module was acceptable.					
29. I have learned how to improve the quality as well as the safety of produce.					

30. Which images did you find most beneficial?

31. Are there any images you didn't find beneficial?

32. What images can be added to increase the appeal and understanding of content in the module?

33. Were there any vocabulary terms that were too complicated?

34. Did any of the sections of the module contain words that were too complex? Which words?

35. Were there any general topics in the module that you found too complicated or need further understanding to grasp the material?

36. Are there any areas of the module that you feel would be improved if additional video was added? Which sections? How user friendly is the online website? What changes do you think should be made to improve convenience and usability?

37. Do you feel that any section of the module is weaker than others? If so, which areas should be further explained?

## What would YOU do?

Read the following case study to see what was done incorrectly, and how changes can make the garden a safer place.

Little Susie rinsed her hands thoroughly with soap and water before going out to the garden to pick fruits and vegetables. Susie entered the garden wearing her sandals and her basket and began picking produce that was ready. As she was harvesting, Susie saw a broken glass bottle in the garden. She safely stepped over it and continued picking the produce.

After awhile of picking produce, Susie was feeling very thirsty. She looked around the garden and saw the garden hose. She went over to it, turned it on, and took a quick drink from the hose.

When Susie finished in the garden, she gave the produce to her teacher to put in a safe place. She then washed her hands under the sink for two seconds before going back to class.

1. What did Susie do wrong?

2. What can YOU do to avoid these problems?

**Figure 3.1. Case study 1 for elementary module.**

## What would YOU do?

Read the following case study to see what was done incorrectly, and how changes can make the garden a safer place.

Brian washed his hands with soap and water before going out to pick fruits and vegetables. He tied his shoelaces tightly, and went into the garden to pick the produce. Brian saw some gardening tools outside of the garden, so he decided to use them on some of the produce items as he went around collecting fruits and vegetables. When finished with the tools, Brian set them down in the garden and went back to picking. After picking produce for some time, Brian heard the class puppy, Scrappy, barking at the gate of the garden. Feeling bad for Scrappy, Brian opened the gate to the garden to let Scrappy walk around the garden while he picked the fruits and vegetables. When Brian finished picking the fruits and vegetables, he left the basket by the entrance to the garden and went inside to wash his hands with soap and water.

1. What did Brian do wrong?
  
  
  
  
  
  
  
  
  
  
2. What can YOU do to avoid these problems?

**Figure 3.2. Case study 2 for elementary module.**



## What would YOU do?

Read the following case study to see what was done incorrectly, and how changes can make the garden a safer place.

Allison woke up with a sore throat on Tuesday morning. Not feeling very well, she decided to go to work and harvest fruits and vegetables. Once arriving at the field, Allison stepped into the garden with close-toed shoes, and started picking produce. Right as she entered the field, Allison heard her pet dog, Heidi, barking for attention. Allison decided to open the gate to the field and let Heidi walk around with her as she continued to pick the produce.

By the time she got to the middle of the field, Allison was extremely thirsty due to her sore throat. Not bringing any water into the field, she glanced down at the gardening hose and took a quick drink out of it.

While she was placing the produce items in the harvesting bins, Allison was receiving a phone call on her cell phone. Excited for the concert she was attending tonight, she decided to pick up her phone and plan the rest of the night's events.

As Allison was walking out of the field with her dog, she spotted a broken glass bottle by one of the crops. Since she still had to take her produce items to post-harvest production, she walked past it with her harvesting bin.

Allison had been picking room temperature produce items. Once it was ready for storage, she put it in a pest-free, well ventilated location on the ground by the pesticides and sanitizers.

The last thing Allison did before finishing for the day was sanitize the post-harvest production facility. She made stronger concentrations than recommended on the back of the container because this will help kill more potential hazards than what was suggested on the bottle. Allison then left the sanitizers to air dry and went home to plan the rest of her evening.

1. What did Allison do wrong?

2. What can YOU do to avoid these problems?

**Figure 3.3. Case study 1 for university module.**

## What would YOU do?

Read the following case study to see what was done incorrectly, and how changes can make the garden a safer place.

Josh woke up feeling very well and ready to work this Thursday. After getting ready, he went to work and ready to pick some fruits and vegetables from the field. As he arrived, Josh walked into the field in his sandals and started picking the produce. Josh left his harvesting bin on the ground because he didn't have a vehicle or bench to put it on. By the time he got to the middle of the field, Josh had to use the restroom very badly. He walked into the portable restroom available. There was not soap present, so he just decided to rub his hands on his shirt and go back to picking the fruits and vegetables. Earlier in the shift, Josh's boss informed him that pesticides were applied to the field prior to his arrival. Josh remembered that the chemical containers were on the other side of the field. He decided that he could leave them in the garden for the night and would pick them up tomorrow when he returns. As Josh was leaving the garden, he saw some rotten tomatoes on the ground by the other fruits and vegetables. He decided to leave them where they were so the nutrients from the tomatoes could benefit the soil. Once the produce got to post-harvest production, Josh put the refrigerated produce in the refrigerator. When it was time to continue production, he removed the most recently refrigerated produce items from storage to continue the processing steps. Josh did not take any records of temperatures, storage times, dates, or cleaning and sanitizing practices.

1. What did Josh do wrong?
2. What can YOU do to avoid these problems?

**Figure 3.4. Case study 2 for university module.**



**Figure 3.5.** Garden hazard graphic for elementary module additional activity.

Elementary >

University >

## Safe Produce - Elementary

IOWA STATE UNIVERSITY

College of Agriculture and Life Sciences

Produce Food Safety for

School and Community

Gardens

02:34

HD :: vimeo

[Introduction](#)  
[Potential Hazards](#)  
[Hazard Prevention](#)  
[Post-Harvest Safety](#)

### Summary

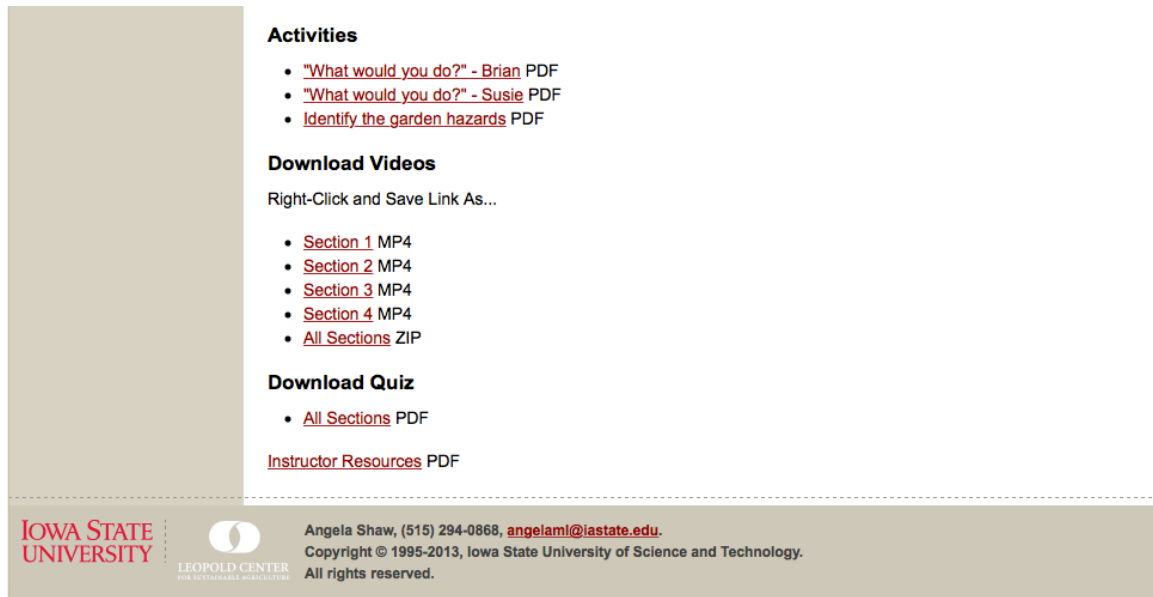
Welcome to the online food safety for school gardens training. School gardens can be important elements of student learning about the food they eat. Food safety with fresh produce has been an increasing concern in recent years. This online training is meant to educate students and their instructors on safe food production handling through the identification of biological, physical, and chemical hazards within the garden.

Through this video you will learn different prevention strategies to reduce risks from occurring. Quizzes will be given at the end of each section of the video to test your knowledge on each area of produce food safety. Additional activities and case studies are provided on the website to assist with further identifying hazards associated with fresh produce. A resource manual is also available on the website to guide the instructors of school gardens on more in-depth information.

Please note that instructors of school gardens should complete a full length Nationally Approved Good Agricultural Practices Short course training to be fully knowledgeable about how to minimize food safety risks within the garden.

If you have further questions about this training, please e-mail Angela Shaw at [angelaml@iastate.edu](mailto:angelaml@iastate.edu), or contact by phone at (515) 294-0868.

**Figure 3.6. Screen shot of online website layout.**



**Activities**

- ["What would you do?" - Brian](#) PDF
- ["What would you do?" - Susie](#) PDF
- [Identify the garden hazards](#) PDF

**Download Videos**

Right-Click and Save Link As...


- [Section 1](#) MP4
- [Section 2](#) MP4
- [Section 3](#) MP4
- [Section 4](#) MP4
- [All Sections](#) ZIP

**Download Quiz**

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[Instructor Resources](#) PDF

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**IOWA STATE UNIVERSITY**  **LEOPOLD CENTER**  
FOR SUSTAINABLE AGRICULTURE

Angela Shaw, (515) 294-0868, [angelaml@iastate.edu](mailto:angelaml@iastate.edu).  
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**Figure 3.7. Screen shot of website additional activities and instructor resource guide.**

# On Farm Food Safety Manual: School Garden



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**Introduction**

Hello! Thank you for your interest in learning how to ensure the safety of those working in the gardens and safety and quality of the products grown. Biological, chemical, and physical hazards potentially associated with school or community gardens are the real threat to your students.

This instructor manual will outline each section of the module (as topics are displayed on the screen), and go into detail about vocabulary terms used throughout the presentation, module outcomes, what you will need to get started, additional exercises not already included in the module, benefits of engaging in the garden safety module, and a risk management plan. This manual will also include answer keys to the four quizzes administered throughout the module.

This project has been funded by the Leopold Center for Sustainable Agriculture at Iowa State University grant program and is titled “Development of an Online Food Safety Training for Employees of University Farms and School Gardens”.



**Vocabulary terms used in the module:**

**Bacteria** – small, single- celled organisms that are able to replicate with other bacteria; they can grow just about anywhere, including soil, water, and in/on food products.

**Compost** – decomposed organic materials made from garden refuse or kitchen food scraps; used to improve garden soil.

**Cross- contamination** – transfer of harmful microorganisms, chemicals, or physical hazards from a contaminated source to another surface that was previously clean.

**Harvest** – process or period of gathering crops; the action of pulling crops from the garden and preparing them for further processing.

**Herbicides** – a chemical substance used to kill weeds.

**Immune system** – a body system that protects humans from foreign substances or microorganisms that can lead to harmful side effects.

**Microorganisms** – a living organism (such as a bacteria, fungi, or virus) that is too small to be seen by the naked eye. To be seen, the use of a microscope is needed.

**Parasite** – a small living animal that needs another organism (known as the host) to survive; the parasite benefits by taking nutrients from the host which can lead to harmful side effects for the host.

**Pesticide** – a general term for a chemical substance used to kill pests, such as weeds, insects, bacteria and fungi.

**Produce** – a general term for fruits, vegetables and herbs.

**Sanitizer** – a chemical agent applied to surfaces to reduce presence of microorganisms to safe levels.

**Virus** – a non-living particle that is microscopic in size that is unable to reproduce without a living host, such as a plant and animal.

## State Educational Requirements:

Some material in this training module may be too complex or detailed for students that have not been exposed to similar subject matter earlier in their education. Educational requirements are based on age and grade, as shown below. Educational Requirements found at <https://www.educateiowa.gov>

### Kindergarten-Grade 2

Students should be able to:

- Ask questions about objects, organisms, and events in the environment.
  - Students should answer their questions by seeking information from their own observations, investigations and from reliable sources of scientific information.
- Plan and conduct simple investigations.
  - Students should be able to design and conduct simple investigations to answer questions.
- Use tools to gather data and extend the senses.
  - Students should use tools, such as magnifiers or microscopes to extend their senses and their abilities to gather data.
- Communicate investigations and explanations.
  - Students should begin to develop the abilities to communicate, critique, and analyze their work and the work of other students. Communication should be conducted orally, through writing or through drawings.
- Understand and apply knowledge of characteristics of living things and how living things are both similar to and different from each other and from non-living things.
  - Living things share some common characteristics that are both similar to and different from non-living things.
- Understand and apply knowledge of the basic needs of plants and animals and how they interact with each other and their physical environment.
  - Organisms have basic needs. Animals need air, water, and food. Plants require air, water, nutrients and light.
  - Organisms can survive only in environments in which their needs can be met.
  - The world has many different environments, and distinct environments in which their needs can be met.
- Understand and apply knowledge of ways to help take care of the environment.
  - Humans depend on their natural and constructed environments.
  - Humans change environments in ways that can be either beneficial or detrimental to themselves or other organisms.
- Understand and apply knowledge of good health habits.
- Understand and apply knowledge of observable and measurable properties of objects.

- Objects can be described by material from which they are made (Size, weight, shape, color, and temperature).

### Grades 3-5

Students should be able to:

- Identify and generate questions that can be answered through scientific investigations.
  - Students ask questions that they can answer with scientific knowledge combined with their own observations.
  - Students recognize that different questions lead to different types of investigations.
- Recognize that scientists perform different types of investigations.
  - Types of objects include describing objects, events, and organisms; classifying them; and doing a fair test (experimenting), depending on the types of questions they want to answer.
- Plan and conduct scientific investigations.
  - Students should engage in systematic observation, making accurate measurements, and identifying and controlling variables.
  - Students understand the concept of a fair test.
- Use appropriate tools and techniques to gather, process, and analyze data.
  - Students enhance their skills with tools such as a magnifier or microscope.
  - Students are introduced to the use of computers and calculators for conducting investigations.
  - Students' use of appropriate tools is guided by the question asked and the investigations students design.
- Use evidence to develop reasonable explanations.
  - Students should judge the merits or strengths of the data and information used to make explanations.
  - Students' explanations should reflect the evidence they have obtained in their investigations.
  - Students should check their explanations against scientific knowledge, their own experiences, and observations of others.
- Communicate scientific procedures and explanations.
  - Students should communicate, critique, and analyze their work and the work of other students.
  - Students should share procedures and explanations through various means of communication.
- Understand and apply knowledge of organisms and their environments.
  - Students should understand the structures, characteristics, and adaptations of organisms, and what allows them to function and survive within their habitats.
  - Understanding of how individual organisms are influenced by both internal and external factors.
  - Students should understand the relationship among living and non-living factors in terrestrial and aquatic ecosystems.
  - An organism's patterns of behavior are related to the nature of that organism's environment, including the kinds and numbers of other

organisms present, the availability of food and resources, and the physical characteristics of the environment. When the environment changes, some plants and animals survive and reproduce, others die or move to new locations.

- All organisms cause changes in the environment in which they live. Some of these changes are detrimental to the organism or other organisms, whereas others are beneficial.
- Understand and apply knowledge of personal health and wellness issues.
- Understand and apply knowledge of how to describe and identify substances based on characteristic properties.
  - The properties of a substance can be measured using tools and technology.
  - It may be necessary to use magnification to observe the component parts of some materials.

## Grades 6-8

Students should be able to:

- Identify and generate questions that can be answered through scientific investigations.
  - Students should develop the ability to refine and refocus broad and ill-defined questions. An important aspect of this ability consists of clarifying questions and inquiries and directing them toward objects and phenomena that can be described, explained, or predicted by scientific investigations.
  - Students should develop the ability to connect their questions with scientific ideas, concepts, and quantitative relationships that guide investigations.
- Design and conduct different kinds of scientific investigations.
  - Students should develop general abilities such as making systematic observations, taking accurate measurements, and identifying and controlling variables.
  - Students should develop the ability to clarify ideas that are influencing and guiding their inquiry, and to understand how those ideas compare with current scientific knowledge.
  - Students formulate questions, design investigations, execute investigations, interpret data, use evidence to generate explanations, propose alternative explanations, and critique explanations and procedures.
- Understand that different kinds of questions suggest different kinds of scientific investigations.
  - Some investigations involve observing and describing objects, organisms and events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.
- Select and use appropriate tools and techniques to gather, analyze and interpret data.
  - The use of tools and techniques, including computers, will be guided by the questions asked and the investigations students design. Students should be able to access, gather, store, retrieve, and organize data, using computer hardware and software designed for these purposes.
- Use evidence to develop descriptions, explanations, predictions, and models.
  - Students should base their explanations on observations and they should be able to differentiate between description and explanation.
  - Developing explanations establishes connections between the content of science and the context in which students develop new knowledge.
  - Models are often used to think about processes that happen too slowly, too quickly, or on too small a scale to observe directly, or are too vast to be changed deliberately, or are potentially dangerous.

- Think critically and logically to make the relationship between evidence and explanations.
  - Students decide what evidence should be used and develop the ability to account for anomalous data.
  - Students should be able to review data from an experiment, summarize the data, and form a logical argument between cause and effect relationships.
  - Students should begin to state some explanations in terms of relationships between two or more variables.
- Recognize and analyze alternative explanations and predictions.
  - Students should develop the ability to listen to and respect the explanations proposed by other students. They should remain open to and acknowledge different ideas and explanations, be able to accept the skepticism of others, and consider alternative explanations.
- Communicate and defend procedures and explanations.
  - Students should become competent in communicating experimental methods, describing observations and summarizing results of investigations. Explanations can be communicated through various methods.
- Understand and apply knowledge of the basic components and functions of cells, tissues, organs, and organ systems.
  - Living systems at all levels of organization demonstrate the complementary nature of structure and function. Important levels of organization for structure and function include cells, organs, tissues, organ systems, whole organisms, and ecosystems.
  - All organisms are composed of cells. Most organisms are single cells; other organisms, including humans are multi-cellular.
  - Cells carry on the many functions needed to sustain life. They grow and divide, thereby producing more cells. This requires that they take in nutrients, which they use to provide energy for work that cells do and to make the materials that a cell or an organism needs.
  - Specialized cells perform specialized functions in multi-cellular organisms. Groups of specialized cells cooperate to form a tissue, such as muscle. Different tissues are, in turn, grouped together to form larger functional units, called organs. Each type of cell, tissue, and organ has a distinct structure and set of functions that serve the organism as a whole.
- Understand and apply knowledge of the complementary nature of structure and function and the commonalities among organisms.
  - Living systems at all levels of organization demonstrate the complementary nature of structure and function. Important levels of organization for structure and function include cells, organs, tissues, organ systems, whole organisms, and ecosystems.
- Understand and apply knowledge of interdependency of organisms, change in environmental conditions, and survival of individuals and species.

- All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment.
- Regulation of an organism's internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required to survive.
- Species acquire many of their unique characteristics through biological adaptation, which involves the selection of naturally occurring variations in populations.
- Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment.
- Understand and demonstrate knowledge of the social and personal implications of environmental issues.
  - The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition. Given adequate biotic and abiotic resources and no disease or predators, populations (including humans) increase at rapid rates. Lack of resources and other factors, such as predation and climate, limit the growth of populations in specific niches in the ecosystem.
- Understand and apply knowledge of the functions and interconnections of the major human body systems including the breakdown in structure or function that disease causes.
  - The human organism has systems for digestion, respiration, reproduction, circulation, excretion, movement, control, and coordination, and for protection from disease. These systems interact with one another.
  - Disease is a breakdown in structure or functions of an organism. Some diseases are the result of intrinsic failures of the system. Others are the result of damage by infection by other organisms.



## Grades 9-12

Students should be able to:

- Identify questions and concepts that guide scientific investigations.
  - Students formulate a testable hypothesis and demonstrate the logical connections between the scientific concepts guiding a hypothesis and the design of an experiment. They should demonstrate appropriate procedures, a knowledge base, and conceptual understanding of scientific investigations. The key is that the student demonstrates knowledge of the scientific concepts through the investigation.
- Design and conduct scientific investigations.
  - Designing and conducting a scientific investigation requires introduction to the major concepts in the area being investigated, proper equipment, safety precautions, assistance with methodological problems, recommendations for use of technologies, clarification of ideas that guide the inquiry, and scientific knowledge obtained from sources other than the actual investigation. The investigation may also require student clarification of the question, method, controls, and variables; student organization and display of data; student revision of methods and explanations; and a public presentation of the results with a critical response from peers. Regardless of the scientific investigation performed, students must use evidence, apply logic, and construct an argument for their proposed explanations.
- Formulate and revise scientific explanations and models using logic and evidence.
  - Student inquiries should culminate in formulating an explanation or model. Models should be physical, conceptual, and mathematical. In the process of answering the questions, the students should engage in discussions and arguments that result in the revision of their explanations. These discussions should be based on scientific knowledge, the use of logic, and evidence from their investigation.
- Think critically and logically to make the relationship between evidence and explanations.
  - Thinking critically about evidence includes deciding what evidence should be used and accounting for anomalous data. Specifically, students should be able to review data from a simple experiment, summarize the data, and form a logical argument about the cause-and-effect relationships in the experiment.
- Recognize and analyze alternative explanations and predictions.
  - This aspect of the standard emphasizes the critical abilities of analyzing an argument by reviewing current scientific understanding, weighing the evidence, and examining the logic so as to decide which explanations and models are best. In other words, although there may be several plausible explanations, they do not all have equal weight. Students use scientific criteria to find the preferred explanations.
- Communicate and defend scientific procedures and explanations.

- Students in school science programs should develop the abilities associated with accurate and effective communication. These include writing and following procedures, expressing concepts, reviewing information, summarizing data, using language appropriately, developing diagrams and charts, explaining statistical analysis, speaking clearly and logically, constructing a reasoned argument, and responding appropriately to critical comments.
- Understand and apply knowledge of the cell.
  - Cells have particular structures that underline their functions. Every cell is surrounded by a membrane that separates it from the outside world. Inside the cell is a concentrated mixture of thousands of different molecules, which form a variety of specialized structures, notably the nucleus, mitochondria, ribosomes, chloroplasts, and the endoplasmic reticulum. Some cells have external structures facilitating movement (cilia and flagella).
  - Most cell functions involve chemical reactions. Food molecules taken into cells react to provide the chemical constituents needed to synthesize other molecules. Both breakdown and synthesis are made possible by protein catalysis, called enzymes.
  - Cells grow and divide.
  - Cell regulation allows cells to respond to their environment and to control and coordinate cell growth and division. Environmental factors can influence cell division.
  - Plant cells contain chloroplasts as sites of photosynthesis. Plants and many microorganisms use solar energy to combine molecules of carbon dioxide and water into complex, energy rich organic compounds and release oxygen to the environment.
- Understand and apply knowledge of biological evolution.
  - Species evolve over time.
  - Evolution is a consequence of: population potential, genetic variability, finite resources and environmental selection.
  - Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms, as well as for the striking molecular similarities observed among the diverse species of living organisms. The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled every available niche with life forms.
  - The millions of different species of plants, animals, and microorganisms that live on earth today are related by descent from common ancestors.
  - Biological classifications are based on how organisms are related. Organisms are classified into a hierarchy of groups and subgroups based on similarities in development and DNA sequences, which reflect their evolutionary relationships. Species is the most fundamental unit of classification.
- Understand and apply knowledge of the interdependence of organisms.

- Organisms both cooperate and compete in ecosystems. The interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years.
- Human beings live within the world's ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology, and consumption. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems will be irreversibly affected.
- Understand and apply knowledge of the behavior of organisms.
  - Multicellular animals have nervous systems that generate behavior. Nervous systems are formed from specialized cells that conduct signals rapidly through the long cell extensions that make up nerves. The nerve cells communicate with each other by secreting specific excitatory and inhibitory molecules. In sense organs, specialized cells detect light, sound, and specific chemicals and enable animals to monitor what is going on in the world around them.
  - The human immune system protects against microscopic and foreign substances entering the body and from cancer cells arising within.

### **Tools Needed:**

A few specific tools and devices are needed to have a successful experience with this training module. They include:

- A lecture computer or other computers capable of accessing the Internet.
- Functioning speakers on computers or additional audio equipment.
- Printer access to print online quizzes for students or computer lab where online quizzes can be taken.
- For Activity #1 in the module, the tools that will be required are:
  - A bottle fluorescent lotion (Brand names include Glo Germ and Glitter Bug – available at [www.glogerm.com](http://www.glogerm.com) or [www.glitterbug.com](http://www.glitterbug.com). A 12 oz. bottle costs about \$15. Internet recipes for making this lotion are available).
  - A black light for visual inspection of hands (These can be purchased from the same sources; prices range from \$7 to \$35).
  - Easily accessed hand-washing station with soap and clean potable hot and cold water.
- For Activities #2 (“When should we wash our hands?”) & #3 (“Produce Detectives: Good or Bad”) in the module, the tools required will be:
  - Writing utensils (pens or pencils).
  - Printed worksheet available on the module website.

**Getting Started:**

Follow these steps to successfully begin running the module:

- Acquire a computer or classroom of computers with Internet capability and sound. Turn the computer(s) on.
- Once the computer(s) are ready, start up the Internet.
- When the Internet is ready, go to <http://www.safeproduce.cals.iastate.edu/elementary/>
- After you have accessed the link, click the play icon in the bottom right corner of the screen to start running the module.
- On the right side of the screen you will see three different tabs labeled, “Quizzes, Activities, and References.” When it is time for students to take the quizzes or do additional activities, click these links for additional information. For further information on garden safety, click the, “References” tab.

**Outcomes:**

By the end of this training module, students should be able to:

- Understand the importance of a healthy diet.
- Identify the number of servings of fruits and vegetables they should consume at every meal.
- List general differences between three different types of harmful microorganisms
- Identify examples of each type (Bacteria, Viruses, and Parasites).
- Understanding the different chemical hazards that can be present when gardening.
- Identify a “physical hazard,” and know what to do if they find these in a school or community garden.
- Describe how cross- contamination can occur in the garden (contaminated water, soil, and direct animal contact, and improper hygienic practices).
- Follow good hygienic practices/ hand washing practices before and after handling the produce.
- Store produce appropriately after it has been harvested.
- Understand the importance of having safe produce items for those that have weakened or lowered immune systems.

**Benefits:**

Additional benefits for students as a result of participation in this learning module are:

- Knowledge of how to properly behave when working in a school or community garden.
- Knowledge of how to handle and use tools for specific purposes.
- Knowledge of how and where to report hazards if they are seen in the garden.
- Active engagement in learning activities (both written and hands on).
- Increased exposure to introductory science vocabulary.
- Knowledge of how to follow proper hygienic practices.

## Overall outline of online module:

Summaries of the slides in the module are divided into sections and identify learning outcomes for each. The summaries outline basic principles behind each section as well as what information the students should learn when viewing the module. Additional information not covered directly in the module is listed below to help divide the module into smaller portions.

The first three slides of the module are used to emphasize the importance of a healthy diet, introduce the topic of where produce comes from, and explain why produce is important in the diet. The Food Guide Plate or My Plate information is included in this section so students can visually see the impact fruits and vegetables have on daily life. For more specific details on the Food Guide Plate, visit <http://www.choosemyplate.gov>.

These slides are intended to introduce students to gardening and ease them into the module, which may be helpful if they are less familiar with gardening or food safety practices. These slides also introduce students to the remaining sections of the module.

Lastly, the introductory section emphasizes why produce food safety is necessary. Students must grasp the concept that if we don't clean the produce well enough, other individuals who consume it have a higher chance of becoming ill. Particularly vulnerable populations with lower immune systems are pregnant women, young children, elderly, and immune-compromised individuals. Pregnant women have a lower immune system because they have to protect their unborn infant as well as themselves. Infants and young children have lower immunity because they are still developing their immune systems. The elderly have a lowered immunity because their bodies are aging and cannot fight off threats to their health as well as other adults. Immune-compromised individuals (such as those with HIV or diabetes) have difficulty fighting off harmful microorganisms. Students need to understand that it is likely some or all of these groups of people may be consuming the produce they are handling and that it is important to take proper steps to prevent people from becoming sick. The upcoming section of this training module will emphasize what action steps can be taken to prevent risks from biological, chemical and physical threats and how students can ensure the produce is clean after it has been harvested. For more information on immune-compromised individuals, please view resources below.



**Resources on Immune-compromised individuals:**

- [www.iowafoodsafety.org](http://www.iowafoodsafety.org) – click on Education and Training and Safe Food Lessons
- [http://www.tchd.org/pdfs/immunosuppressed\\_precautions\\_to\\_prevent\\_disease.pdf](http://www.tchd.org/pdfs/immunosuppressed_precautions_to_prevent_disease.pdf)
- <http://www.foodsafety.gov/poisoning/risk>

**Quiz 1**

The first quiz focuses on information covered in the introductory slides. The 10 multiple choice questions on the quiz will give students a general understanding of why produce safety is important and how food safety can be assured with food. Below is the answer key for the first quiz over introduction to the training module. Quiz questions for elementary module: QUIZ 1

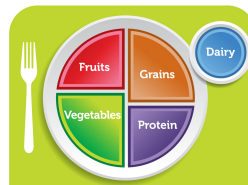
- 1) Why is it important for us to eat fruits and vegetables?
- Because my parents told me to.
  - Because they can help keep me healthy and strong.
  - Because I can't find any other food.
  - It's not important to eat fruits and vegetables.

Answer: As mentioned early in the training module, fruits and vegetables provide us with nutrients that our body needs to stay healthy.

- 2) What will eating fruits and vegetables help do?
- Keep me from getting some diseases when I am older.
  - Keep me from becoming obese or gaining weight.
  - Keep important vitamins and minerals in my diet.
  - All of the above.

Answer: Fruits and vegetables offer many benefits in addition to keeping us healthy and strong. Biochemically, the nutrients, vitamins, and minerals will work in the body and will reduce the chances of various diseases from occurring later in life. Fruits and vegetables are a healthy choice instead of candy. By eating produce items instead, becoming obese is much more unlikely.

- 3) What is this diagram called?
- MyFood.
  - MyDiagram.
  - MyPlate.
  - MyCourse.



Answer: This diagram is called the “MyPlate.” This diagram shows each food group, and how much should be consumed per meal.

4) According to the MyPlate diagram, I need to eat \_\_\_\_\_.

- a. More fruits than vegetables
- b. More vegetables than fruits
- c. The same amount of fruits and vegetables
- d. It doesn't matter as long as I eat something

Answer: Even though fruits and vegetables are both important to stay healthy, we should be eating more vegetables than fruits. The MyPlate diagram shows that  $\frac{1}{2}$  of the plate should be focused on fruits and vegetables, but more vegetables should be eaten when looking specifically at fruits and vegetables.

5) About what percent of our food should be made up of vegetables according to this diagram?

- a.  $\frac{1}{4}$  of the plate.
- b.  $\frac{1}{3}$  of the plate.
- c.  $\frac{1}{2}$  of the plate.
- d.  $\frac{7}{8}$  of the plate.

Answer: After analyzing the MyPlate diagram, we can see that half of total food eaten should come from fruits and vegetables. The other half should be dedicated to grains and protein (with dairy as a subsection).

6) Michael and Laura are eating lunch. They are the same age and are both physically active. Who should eat more produce?

- a. Michael because he's a boy.
- b. Laura because she's a girl.
- c. Michael and Laura should eat the same amount of produce.
- d. Michael because Laura had hash browns (potatoes) for breakfast.

Answer: Nutritional requirements differ depending on the sex of the individual. Men require higher amounts of fruits and vegetables than women at the same age and physical activity level. In this example, Michael would require more fruits and vegetables than Laura.

7) What should be done to make sure people don't get sick from eating contaminated fruits and vegetables?

- a. Handle fruits and vegetables properly, by washing hands frequently.
- b. Wash fruits and vegetables before we eat them.
- c. Throw away fruits and vegetables that look bad.
- d. All of these can help make sure people remain healthy and safe.

Answer: All of these steps should be followed to reduce the risks of illness. Many foodborne illnesses occur due to poor personal hygiene. By washing hands frequently, the likelihood of transmitting harmful agents to produce items is much reduced. Rinsing off fruits and vegetables before they are consumed will reduce the chances of having other physical, chemical, or biological hazards on the produce. Throwing away fruits and vegetables that look bad is a good idea. These produce items are more than likely rotten or contaminated. These should not be eaten. Bad fruits and vegetables should be properly thrown away or placed in a designated compost for use at a later time.

- 8) Sophia grabs an apple out of the fridge and takes a bite. Is this healthy?
- Yes, apples make us healthy and strong!
  - No, apples are too sugary to be healthy.
  - No, she should have sliced the apple to make sure it was fresh.
  - No, she should have washed the apple before eating it.

Answer: Even though fruits and vegetables are good for us, we have to make sure to be safe when eating them. In this example, Sophia doesn't know how the apple was handled or where it has been prior to her refrigerator. She should make sure to wash it before eating to reduce any harmful chemicals, debris, or microorganisms that may be on the surface of the apple.

- 9) Jose's older brother, Miguel, is mad that their mom gave him an extra scoop of vegetables. Should Miguel be mad?
- Yes, the boys should have gotten the same amount of vegetables.
  - Yes, the extra vegetables took the space where he was going to put his dessert.
  - Yes, Jose should have gotten the extra scoop.
  - No, Miguel should have more vegetables because he is older.

Answer: As people get older, they require more vegetable intake. In this example, Miguel should not be mad. He is older than Jose, and requires more vegetables at his older age.

- 10) Why is it important for us to do everything we can to keep the fruits and vegetables safe?
- Because we could get in trouble by the teacher if we don't.
  - Because we don't want to make ourselves or others sick if we don't follow these steps.
  - Because the fruits and vegetables will look better if we do.
  - None of the above are very important.

Answer: We have to keep produce safe so we don't make ourselves or others sick. Remember, everybody has different immune systems. Some people will be

more sensitive to harmful microorganisms than others (young, elderly, pregnant, immune-compromised). The fruits and vegetables have to be kept safe enough for all immune systems.

## Section 2

The next section of the module provides more in depth information about biological hazards associated with fruit and vegetable production. After viewing the online module, students should learn the overall meaning of a microorganism, the different types of microorganisms that can contaminate produce items in the garden, and understand why prevention of harmful microorganisms on produce is extremely important. Students should understand that just because we can't see them, harmful microorganisms could still be on the produce.

Students are not expected to already know examples of each type of microorganism, but this module introduces them to a few harmful common microorganisms that can lead to illness or death in consumers.

The three bacterial microorganisms that are listed as examples in the training module are: *E. coli* (pronounced ee-coe-lie), *Listeria* (list-ear-ee-a) *monocytogenes* (mono-site-aw-gen-ease), and *Salmonella* (sal-ma-nel-a). These examples were chosen because they are some of the most harmful pathogens that have been associated with fresh produce. The specific strain of *E. coli* of concern is *E. coli* 0157:H7. This pathogen has a very low infectious dose, which means it takes very few cells to cause illness in consumers. Some common symptoms associated with *E. coli* 0157:H7 are: bloody diarrhea and abdominal cramps. In the elderly and young children, hemolytic uremic syndrome (HUS) can occur, which will lead to death of red blood cells, and will eventually result in kidney failure.

*Listeria monocytogenes* is a strain of bacteria that can also cause some very serious health issues. If an individual ingests *Listeria monocytogenes*, some common symptoms such as fever, muscle aches, a stiff neck, loss of balance, convulsions and/or diarrhea may be present. *Listeria monocytogenes* is of serious risk to pregnant women because ingestion can lead to miscarriage and stillbirth of the fetus.

*Salmonella* is another type of bacteria that can be harmful if ingested; common symptoms are bloody diarrhea, fever, and abdominal cramps. These symptoms will usually occur 12 to 72 hours after ingestion of *Salmonella*. Depending on the strain of *Salmonella*, symptoms may either occur shortly after ingestion or may take awhile for the body to process.

The only virus included in the students' training module is Norovirus. Norovirus is used as the virus example because it is one of the most common occurring foodborne outbreak microorganisms. Norovirus is spread by fecally contaminated food or water, or from cross-contamination from one person to another person. According to the Centers for Disease Control and Prevention (CDC), some of the

symptoms associated with Norovirus are diarrhea, vomiting, nausea, and stomach pain. Other symptoms may include fever, headache, and body aches.

The last example of harmful microorganisms is the parasite, *Toxoplasma gondii* (toxo-plasma gone-dee). *Toxoplasma gondii* is a parasite that originates in cats, but can then be transmitted from cats to humans via fecal contamination. For this reason, it is extremely important to keep felines and other wild animals away from the produce and the garden. The symptoms of *Toxoplasmosis* are similar to that of the common flu. People with healthy immune systems may not even know they have been infected. However, this infection causes bigger problems in pregnant women and those with lowered immune systems.

After being introduced to these different microorganisms, students should understand that there are a wide variety of microorganisms that can cause illness, and that individuals' immune systems offer varying degrees of protection. By the end of this section, students should know the basic differences between bacteria, virus, and a parasite and which are harmful. Not all microorganisms are harmful. However, some of those that are harmful typically live in soil, water, or in humans. Therefore, it is important that those working in the garden understand the raw agricultural products grown in nature do have some risk and they have a role in making sure fresh products are safe.

Please view the resources listed below for additional information on microbial hazards.

#### **Microbial hazards resources:**

- <http://www.extension.iastate.edu/foodsafety/lesson/l1/l1p1.html>
- <http://www.maricopa.gov/publichealth/Services/Nutrition/Garden/pdf/minimizing-microbial-food-safety-hazards-in-the-school-garden.pdf>
- <http://www.cdc.gov>
- <http://digestive.niddk.nih.gov/ddiseases/pubs/bacteria/>

The next section of the module describes the chemical hazards that can occur in gardens. No specific chemical is addressed to the students, but they will learn about the importance of proper application and storage. Students should not be applying chemicals nor be present when this is done, but they should be aware chemicals can be a useful gardening tool, must be handled correctly, and applied only by teachers or certified individuals.

Students should also know that not all plant parts in the garden are edible and some parts of certain plants can make them sick. Some parts of plants that grow in the school garden may contain toxins, such as the unusual tomato-like fruit on a potato plant. Remind students not to eat anything while in the garden and wait to eat any crop until after it has been properly cleaned.

For additional information on chemical hazards, please follow the resources provided below.

**Chemical hazard resources:**

- [http://www.crec.ifas.ufl.edu/extension/trade\\_journals/2010/2010%20April%20food%20safety%20hazards.pdf](http://www.crec.ifas.ufl.edu/extension/trade_journals/2010/2010%20April%20food%20safety%20hazards.pdf)
- <http://www.kidsgardening.org/node/57664>
- <http://www.who.int/ceh/risks/cehchemicals2/en/index1.html>

**NOTE:** For additional information on chemical application or chemical concerns, please visit: [www.epa.gov](http://www.epa.gov).

The last type of hazard that may be present in gardens are those of a physical nature. There are many natural physical hazards that can be found in the garden. This module gives examples of natural and manmade waste materials that have potential to be physical hazards. Some of the natural physical hazards in gardens are sticks, stones, rocks, and sharp parts of the plant. Some potentially harmful manmade waste products that could be in the garden soil are broken glass, sharp hard plastic, and metal, particularly if the garden is in a former vacant lot. Students are reminded that if they do encounter a physical hazard, they are NOT to touch or pick it up. The message students need to understand from the physical hazards section is that if they see any hazardous material in the garden, they need to let you, the instructor, know so it can be removed in a safe manner. It is important to inform students that they should not bring any food or liquid containers into the garden with them because containers can break and result in a physical hazard in the garden.

After watching the video clip on this slide, students should understand that gardening tools can cause physical harm if not used for their specific purpose or stored appropriately when not being used, that physical hazards can be due to manmade or natural items, and that food and beverage containers should be kept out of the garden.

For other potential physical hazards that may be found in the garden, visit the resource listed below.

**Physical hazard resource:**

- <http://web.uri.edu/foodsafety/food-safety-hazards/>

Upon completion of this section on hazards, students should have a general knowledge of various biological, chemical, and physical hazards they may encounter in the school or community garden. Students must learn these main messages; these are emphasized in the second quiz of the training module, which can be administered at this point in the training.

Below is the answer key for the administered quiz over the different types of hazards that can occur in the garden.

**QUIZ 2**

Quiz questions for elementary module: QUIZ 2

- 1) What are the three ways that can make us sick or hurt us when in the garden?
- a. From people, fruits, and animals.
  - b. From microbial, chemical, and physical hazards.
  - c. From water, gloves, and garden tools.
  - d. None of these can make people ill or hurt.

Answer: The three main ways to get hurt or sick in the garden are from microbial, chemical, and physical hazards. A few ways microbial illness can occur from are contamination and spoilage of produce. Chemical hazards can result from herbicide and pesticide misuse or improper sanitation. Physical hazards can occur in the garden from improper usage of tools or harmful sharp glass or plastic garbage left or thrown into the garden.

- 2) Where, besides on the produce itself, can bacteria be found in the garden?
- a. In the soil
  - b. In the water
  - c. On the tools
  - d. All of the above

Answer: Bacteria can be found many places around the garden. It can be found in the soil, in water we use, and on our tools if they are not cleaned properly. When working in and around fresh produce, we have to make sure to clean tools appropriately and make sure the water we in our process is microbially safe for humans.

- 3) What tool would we have to use to see harmful microorganisms on our food?
- e. Our eyes
  - f. A magnifying glass
  - g. A microscope
  - h. There's no way to see them, but we have to act like they are, just in case.

Answer: Microorganisms are very small, and cannot be seen with just our eyes. We have to use microscopes to see what microorganisms are on our food samples.

- 4) What are the names of some bacteria that could be harmful to people if eaten?

- a. *Listeria monocytogenes* and *Salmonella*
- b. *Streptococcus thermophiles* and *Brevibacterium linens*
- c. *Acetobacter aceti* and *Vibrio fischeri*
- d. All of the above can cause harm to people.

Answer: From the options above, only *Listeria monocytogenes* and *Salmonella* are harmful to people if they are eaten. *Streptococcus thermophiles* is a bacterium that is used in the production of yogurt, and *Brevibacterium linens* is used to ferment different cheese products. *Acetobacter aceti* is used to produce vinegar, and *Vibrio fischeri* will make aquatic microbes glow when activated. Only option A contains microorganisms that can make people sick if eaten.

- 5) What is the most common and harmful type of virus related to produce?

- a. Influenza virus.
- b. Norovirus.
- c. Tobacco Mosaic Virus.
- d. West Nile Virus.

Answer: The most common type of virus related to produce contamination is Norovirus. It can be transferred from infected people, contaminated water, or from touching contaminated surfaces.

- 6) Which of the following is an example of a parasite that could be harmful if eaten?

- a. *Toxoplasma gondii*.
- b. *Bacillus cereus*.
- c. *Listeria monocytogenes*.
- d. *Escherichia coli*.

Answer: *Toxoplasma gondii* is the only parasite in the options provided. *Bacillus cereus*, *Listeria monocytogenes*, and *Escherichia coli* are all different types of bacteria that can lead to illness if eaten.

- 7) What in the human body helps fight off bad microorganisms?

- a. The nervous system.
- b. The immune system.
- c. The pathogen elimination system.
- d. The body can't fight off bad microorganisms.

Answer: The immune system helps the body fight off harmful microorganisms that may be eaten. Some people have stronger immune systems than others. For this reason, produce has to be made safe enough for even people with the weakest immune systems (young, elderly, pregnant, immune-compromised).



- 8) What can be applied to protect crops from insects or disease-causing organisms, and who should use them?
- a. Insecticides; anyone can use them.
  - b. Insecticides; only adults should use them.
  - c. Sanitizers; anyone can use them.
  - d. Sanitizers; only adults can use them.

Answer: Insecticides should be used to protect produce from insects. Sanitizers should be used on gardening tools and equipment, NOT on the produce itself. These insecticides should only be applied by teachers or approved adults. Students should never apply insecticides.

- 9) What are some physical objects that may be found in the garden and that could hurt you?
- a. Broken glass.
  - b. Sharp sticks and stones.
  - c. Metal fragments.
  - d. All of the above.

Answer: All of the above are possible physical hazards that may be found while gardening. Broken glass, sharp sticks and stones and metal fragments are all physical hazards that can result in cuts or wounds if stepped on or picked up. If students see these hazards in the garden, they should NOT pick them up. Students should tell an adult or instructor so the physical hazard can be removed safely.

- 10) Whose health do we have to worry about when growing produce?
- a. The people eating the produce
  - b. Our own
  - c. Other people who come into contact with the garden or products
  - d. All of the above

Answer: We have to consider the consumer, ourselves, and other individuals that come in contact with fresh produce when growing produce. People have different levels of immune systems, and we have to consider that somebody with a lowered immune system may come in direct contact with the fresh produce. We want to reduce food safety risks when considering everybody that will come in contact with our fresh produce.

### Section 3

The next section introduces natural hazards and the steps necessary to prevent contamination of garden produce. Each natural hazard will be discussed in greater detail, emphasizing how the hazard can arise, and what students must do to prevent the hazard from affecting the produce.

The first natural hazard that may be present is water contamination. Students will learn about water quality. A take home message is that they shouldn't drink from the garden hose when they are watering the garden plants. Students may not realize it, but if they drink from the hoses when watering the produce, some microorganisms that are in their mouth or on their face could cross contaminate the produce, making it unsafe. Further, the hose itself may be contaminated so the water they are drinking may not be safe. An additional activity in the module will also show students that surface water (pond water) should not be used because of the different types of microorganisms that may be in it.

The only type of water that should be used on your school garden is municipal (city) water. If you are using water from a hose or a sink from the school, the water should be safe for drinking. Do NOT use water that has come from a well unless it has been tested and proven safe; without testing, well water may contain levels of microorganisms that are deemed unsafe to use on your produce items. And under all circumstances, NEVER use standing water from ponds or ditches. Standing water will contain high numbers of microorganisms, increasing the likelihood of pathogen presence in the water.

For additional information on water resources, please follow the links below.

#### Water contamination resources:

- [www.iastatelocalfoods.org](http://www.iastatelocalfoods.org)
- <http://www.cdc.gov/healthywater/other/agricultural/contamination.html>
- [http://www.chewonki.org/cleanwater/water\\_pollution.asp](http://www.chewonki.org/cleanwater/water_pollution.asp)

The next natural hazard presented is the soil that is already in the garden. Students will learn about microorganisms naturally found in soil, and action steps needed to ensure students keep themselves and the produce free from potentially harmful microorganisms. The first aspect of soil you should consider when choosing a location for the garden is prior land use. It is important to do background research on the location of the garden to make sure it wasn't previously a site where harmful chemical or biological hazards would reside.

Other chemicals, such as lead from paint, heavy metals, or nitrites in the soil can also be harmful.

The take home message for students is to always wash their hands thoroughly after working in the garden because of contact with soil. Proper hand washing is emphasized in the next section of the teaching manual.

Below are links to additional resources on soil contamination.

**Soil contamination resources:**

- [http://www.euro.who.int/\\_data/assets/pdf\\_file/0009/119187/E64737.pdf](http://www.euro.who.int/_data/assets/pdf_file/0009/119187/E64737.pdf)
- [http://cwmi.css.cornell.edu/Soil\\_Contaminants.pdf](http://cwmi.css.cornell.edu/Soil_Contaminants.pdf)
- [http://louisville.edu/cepm/publications/practice-guides-1/PG25%20-%20Urban%20Agriculture%20-%20Soil%20Contamination.pdf/at\\_download/file](http://louisville.edu/cepm/publications/practice-guides-1/PG25%20-%20Urban%20Agriculture%20-%20Soil%20Contamination.pdf/at_download/file)

The last natural hazard that will be introduced to students in this section of the online learning module is potential contamination from wild animals. Wild and domestic animals can pass harmful microorganisms to the produce from fecal material, from their mouths, fur or skin, or from unclean paws. Fecal material will contain the pathogen, *E. coli* 0157:H7, which can make people very ill. The best way to combat animal contamination is to have clear policies about no pets allowed and to set up physical barriers, like fences, to keep them out of the garden. A two-foot high chicken wire fence that is buried a couple of inches will keep rabbits from the garden, but a 6 to 8-foot tall fence might be needed if deer are present in your area. After viewing the training module, students will get an understanding of why all animals need to stay out of the garden, and the potential harm they can cause if allowed in the school or community garden. Directly below are additional resources for more information on animal contamination.

**Animal contamination resources:**

- <http://gardening.wsu.edu/stewardship/compost/petpoop.htm>
- [http://www.epa.gov/safewater/sourcewater/pubs/fs\\_swpp\\_petwaste.pdf](http://www.epa.gov/safewater/sourcewater/pubs/fs_swpp_petwaste.pdf)
- <http://mtwatercourse.org/media/downloads/Pet%20Waste.pdf>

A common way cross-contamination occurs with produce items is from poor hygienic practices. The next section of the module is dedicated to informing the students about the *importance* of washing their hands, *how* to properly wash their hands, and *when* to wash their hands. Poor hygienic practices are one of the largest causes of cross-contamination to food. Because produce often is not cooked before eating, it is important that cross-contamination of harmful microorganisms be controlled. DO NOT allow students to work in the garden if they show any symptoms of illness.

This section of the module will introduce examples of how cross-contamination can occur between dirty surfaces and clean produce. Students will learn how to properly and thoroughly wash their hands with potable water, soap, and clean paper towels. To put this into practice, make sure adequate hand-washing supplies are available to the students and that there is time scheduled to wash hands before harvesting any produce and after they work in the garden.

The best way to reduce the number of potentially harmful microorganism on hands is through the use of soap and water. Alcohol based sanitizers can help quickly reduce the number of most microorganisms on hands yet sanitizers are not effective

in reducing levels of norovirus, one of the viruses commonly associated with produce. Therefore, hand washing is the best practice and teachers should schedule time for hand-washing to occur before and after garden instruction. Below is a list of different personal hygiene resources for additional information.

**Personal Hygiene resources:**

- <https://store.extension.iastate.edu/ItemDetail.aspx?ProductID=13687>
- <http://www.health.gov.au/internet/publications/publishing.nsf/Content/ohp-enhealth-manual-atsi-cnt-l~ohp-enhealth-manual-atsi-cnt-l-ch3~ohp-enhealth-manual-atsi-cnt-l-ch3.2>
- [http://www.health.vic.gov.au/foodsafety/downloads/hygiene\\_personal.pdf](http://www.health.vic.gov.au/foodsafety/downloads/hygiene_personal.pdf)
- <http://www.bromley.gov.uk/leaflet/260991/13/756/d>
- [http://www.northdevon.gov.uk/index/lgcl\\_environment/nonlgcl\\_environmental\\_health/nonlgcl\\_food\\_hygiene\\_and\\_safety/nonlgcl\\_food\\_safety\\_tips/nonlgcl\\_food\\_safety\\_tips\\_personal\\_hygiene.htm](http://www.northdevon.gov.uk/index/lgcl_environment/nonlgcl_environmental_health/nonlgcl_food_hygiene_and_safety/nonlgcl_food_safety_tips/nonlgcl_food_safety_tips_personal_hygiene.htm)

This slide describes the proper 6-step hand-washing process. To have a successful hand-washing experience, students need to have access to necessary supplies: potable water with soap and disposable towels. In the first step, rinsing hands under hot running water (or clean water if hot is not available) removes the initial presence of microorganisms from their hands. The soap loosens soil from hands with lathering action; the 10 to 15 seconds of lathering is needed to allow the cleaning agents to work effectively, in addition to ensuring that all areas on the hand and wrists have received some of the soap.

Cleaning under fingernails and in between fingers is important because these areas allow places for microbial growth. Rinsing off excess soap and loosened soil results in clean hands. Using disposable paper towels or hot air dryers ensures hands are not re-contaminated from soiled linens.

For further information on hand washing, please view the below resources.

**Hand-washing resources:**

- <http://www.extension.iastate.edu/foodsafety/consumers/index.cfm?parent=280>
- <http://www.cdc.gov/features/handwashing/>
- <http://www.bidmc.org/YourHealth/Holistic-Health/How-to-Wash-Your-Hands-Properly.aspx>
- <http://homefoodsafety.org/safety-tips/wash>
- <http://www.cleanhandscampaign.org/wash.htm>

After completing the section on personal hygiene, students will have the opportunity to engage in some interactive exercises to reinforce these concepts. Two engagement activities are included in this portion of the module. Students will

apply a fluorescent lotion product to their hand (one brand is called Glo Germ™ or you can make this in house with fluorescent paint) and rub it into their skin. To successfully perform this activity, you will need the fluorescent lotion, a black light, antibacterial soap, and a potable water source.

To purchase fluorescent lotion, go to this link (various kit options are available based on what is needed): <http://glogerm2.hostica.com/mm5/merchant.mvc>.

When placed under a black light, the fluorescent lotion will show simulated germs or microorganisms on the student's hands. After students follow the 6-step hand-washing method in the module and place their hands under the black light again, there should be no presence of any lotion on their hands. This activity specifically helps students learn the correct way to wash their hands effectively.

Many times, people forget to wash their hands after simple tasks. The second activity in this portion of the module will show students the importance of *when* to wash their hands and *why* frequent hand washing is important. To successfully perform this activity, students will need printed sheets from the "Activities" tab on the right side of the module menu. Students will also need a pencil or pen. You can choose to either make this a small group activity or an individual activity based on your preference or the age group of the students.

There are plenty of objects that can be found in the garden that can potentially cut or scratch students. As the teacher, it is important for you to make sure to reinforce that students do not touch any of them. It is your duty to safely remove any potentially harmful objects from the garden to reduce the chances of potential injury. These objects should be removed with gloves, and placed in a proper waste bag or receptacle, and disposed of in the appropriate location.

It is important to emphasize to students that horseplay will not be tolerated in the garden and to stay away from any fences. Fences are meant to protect the produce from any wildlife or domestic animal, as well as to reduce the chance of vandalism; they are not intended as a recreational item.

Fences are not as sturdy as they might appear. They may topple over or could scratch or cut a student if they are playing on them.

Students must also wear protective clothing when gardening. The biggest physical concern when working in the garden is of students wearing sandals. Students should put closed toed shoes on before entering the garden. Shoes are the best option because they can protect the student from physical hazards, such as rocks, thorns, or sharp branches. By wearing adequate amount of protective gear, they will reduce the chances of an accident.

**QUIZ 3**

The third quiz consists of questions over specific biological, chemical, and physical hazards and how to minimize risks from these hazards. There will also be a few questions covering poor personal hygiene including some related to the two activities about cross-contamination because this is a big concern when handling fresh produce. Please make sure to pause the module at this time until students have completed the quiz. The answers to the third quiz are given below.

- 1) How can drinking from hoses make people sick from fruits and vegetables?
- a. Microorganisms will form more quickly in hoses than in other places.
  - b. Microorganisms from our mouth can transfer to the fruits and vegetables and contaminate them.
  - c. Drinking from hoses can't make people sick.
  - d. None of the above.

Answer: Drinking from hoses can make people sick because harmful microorganisms in our mouth can transfer to the produce. Unintentionally, water can help transfer microorganisms from our mouth to the surrounding soil, or even directly onto the produce. Nobody should ever drink from the hoses that are used on the garden produce.

- 2) Why should fruits and vegetables not be set in soil after taken off the vine?
- a. Contaminated soil can affect fruits and vegetables that were originally safe.
  - b. Contaminated fruits and vegetables can make the soil unsafe.
  - c. Other physical hazards could come in contact with the safe produce.
  - d. All of the above.

Answer: All of the above are reasons why produce should not be placed in soil after being picked. The soil may have already been contaminated. By placing the produce on the soil, it is exposed to potential physical, chemical, and biological hazards.

- 3) Are all microorganisms harmful?
- a. Yes, all microorganisms are harmful.
  - b. No, there are no harmful microorganisms.
  - c. There are some harmful microorganisms, but most will not make us sick.
  - d. There are more microbes than harmful ones.

Answer: Not all microorganisms will cause harm if we eat them. Some microorganisms are used to help make food products, such as cheese and yogurt. There are some harmful microorganisms, but a majority of them will not cause harm or illness if eaten.

- 4) Which of the following is NOT a risk associated with animals in the garden?
- a. Animal's poop.
  - b. Spread of microorganisms from paws to fruits and vegetables.
  - c. Contamination of soil in the garden.
  - d. All of the above are risks associated with animals.

Answer: All of the above are risks with having animals in the garden. Animal poop contains many microorganisms. If the animals poop in the garden, it will contaminate the garden soil, which can result in harmful microorganisms on the produce. The paws on animals are also not regularly washed like our hands are. Paws may have harmful bacteria, viruses, or parasites on them and then transferred to the soil when the animals steps into the garden.

- 5) Where should fruits and vegetables be placed after picked from the vine?
- a. On the ground, outside of the garden.
  - b. On the ground, inside of the garden.
  - c. In a separated bin away from rotten or ruined produce.
  - d. Any of the above are ok locations to place picked fruits and vegetables.

Answer: After picked, produce should never be placed back onto the ground. Placing produce on the ground can result in contamination by physical, chemical, or biological hazards. Storing produce in a clean, separated bin away from rotting or bad produce will reduce the chances of contamination from occurring.

- 6) Why should most produce be rinsed after it has been collected?
- a. Because of potentially harmful microorganisms from the garden.
  - b. Because of potentially harmful microorganisms on your hand.
  - c. Because of potentially harmful microorganisms from gardening tools.
  - d. All of the above.

Answer: Produce should be thoroughly rinsed after collection for all of the above reasons. Harmful microorganisms can be present in the garden (some of them are found naturally).

People touch many objects throughout the day. If proper hygienic practices are not followed, students could transfer harmful microorganisms from their hands onto the freshly picked produce.

When gardening tools are not properly sanitized after use, they could have come in contact with chemicals or harmful microorganisms that are in the garden soil. The chances of physical, chemical, and biological hazards are significantly reduced if produce is rinsed after it has been picked.

- 7) Sam used warm water and soap to wash his hands. He made sure that he rubbed soap on the front and back of his hands and between his fingers for 10-15 seconds; then he rinsed them and dried them with a paper towel. What did Sam do wrong?

- a. He did nothing wrong.
- b. He should have scrubbed his wrists and arms too.
- c. He should have let them air dry.
- d. He forgot to scrub under his fingernails.

Answer: When washing our hands, we have to make sure to clean hard to reach places, including under our fingernails. When handling fresh produce, we may have harmful microbes under our fingernails without even knowing. By scrubbing under fingernails, we can reduce the risk of cross-contaminating the fresh produce we handle.

- 8) What is the length of time needed for hands to be lathered once soap has been applied?
- a. 3-5 seconds, or about the length of "Hello. My name is \_\_\_\_\_."
  - b. 10-15 seconds, or about the length of the, "Happy Birthday" song.
  - c. 1 minute.
  - d. Place hands under water for as long as you want.

Answer: To properly use soap, it should be lathered for 10-15 seconds. Lathering will allow the antimicrobial properties to get to the hard to reach spots on the hand. Singing, "Happy Birthday" to yourself is an easy way to make sure enough time is spent lathering.

- 9) Fences are a helpful tool for keeping animals out of the garden. What do we have to remember when working around fences?
- a. Wear protective clothing
  - b. Fences are not jungle gyms
  - c. Fences could have sharp objects so we shouldn't touch them.
  - d. All of the above.

Answer: As beneficial as fences can be, they can also be a physical hazard if we are not careful around them. To avoid physical injury, we should wear protective clothing when around them. Additionally, fences are not a toy; to avoid sharp edges, we should not play or touch them while working in the garden.

- 10) How should gardening tools be stored when not in use?
- a. They can be left anywhere.
  - b. Placed in a designated location to avoid physical hazards.
  - c. Leave them the last place they were used to pick fruits or vegetables.
  - d. All of the above.



Answer: Gardening tools must be placed in a designated location when not in use. Fewer physical hazards will occur because students and teachers will be aware of dangerous tools in the area. It is important not to leave tools in the garden, because they will be hard to see and people may step on them. Also, NEVER leave sharp side upward.

#### **Section 4**

This section of the learning module describes practices after the produce has been harvested. The first portion of this section will teach students about the importance of distinguishing between good quality and poor quality produce items. This knowledge can reduce chances of contamination. In addition, students can add poor quality produce items to the compost pile to improve the garden soil. The good produce will be gathered for further cleaning later. These fruits and vegetables are fully mature and ripe, with minimal insect damage or bruising. It is important for students to be able to recognize inferior fruits and vegetables for more than just the quality aspect. These items need to be kept away from good produce items so cross-contamination cannot result.

Students can complete a third interactive exercise that allows them to visualize different produce items and see if they can properly evaluate whether these are acceptable products or poor quality produce items. To successfully complete this activity, a printer will be needed to copy activity sheets from the, "Activity" tab on the right side of the module. This can also be done via computer as a large group or class activity if everyone can view the pictures. If done individually, students will either need a pen or pencil, or a personal computer if the activity is done in a computer lab. Please pause the module at this time until the activity has been completed and discussed.

The purpose of this slide is to allow students to see examples of produce items and determine why they are "good," or, "bad." The narrator will speak (as written in the script) and hold up the produce items in the order they are listed in the interactive exercise.

The last topic that will be covered in this module is how fruits and vegetables should be stored after they have been harvested. It is important to practice, "first in, first out," inventory management with students to help them understand produce items will only maintain an acceptable quality for a certain amount of time. The, "first in, first out," procedure means produce items initially placed in the storage location must be the first ones removed. If this practice is followed, less produce will be wasted because it will be used before it spoils. As the instructor, it is important to check the storage location frequently and make sure this practice is followed as well as check that appropriate cleaning practices are followed to avoid cross-

contamination from unclean surfaces. The instructor should also check proper storage temperatures are maintained.

To learn more about produce storage, follow the links to the resources listed below.

**Produce storage resources:**

- <http://ucce.ucdavis.edu/files/datastore/234-1920.pdf>
- [http://msue.anr.msu.edu/news/proper\\_produce\\_storage](http://msue.anr.msu.edu/news/proper_produce_storage)
- [http://www.kent.k12.wa.us/cms/lib/WA01001454/Centricity/domain/9/f2s%20images/Fresh%20Produce%20Storage%20Tips\\_WSDA.pdf](http://www.kent.k12.wa.us/cms/lib/WA01001454/Centricity/domain/9/f2s%20images/Fresh%20Produce%20Storage%20Tips_WSDA.pdf)

Fresh Produce Safety – CDC and FDA sites:

- <http://www.cdc.gov/features/foodsafetyquiz/>
- <http://www.fda.gov/Food/ResourcesForYou/Consumers/ucm114299>

The students will learn why produce should always be rinsed before consumed to reduce the chances of becoming ill from any of the potential hazards. They will learn how to properly store and rinse and store garden produce.

The kitchen or wash area needs to be completely cleaned before bringing produce in. Cleaning surfaces and applying sanitizers where produce will be placed further reduces chances of cross-contamination from harmful microorganisms or chemical agents. It is also important to thoroughly wash all surfaces after produce have been placed in appropriate storage. This will reduce potential microbial growth and cross-contamination on future produce items and reduce chances of infecting students' hands.

For additional information on kitchen sanitation, please refer to the resources listed below.

**Kitchen sanitation resources:**

- [http://www.ohio.edu/riskandsafety/docs/food\\_forms/studentkitchensanitationguidelines0207.pdf](http://www.ohio.edu/riskandsafety/docs/food_forms/studentkitchensanitationguidelines0207.pdf)
- <http://www.extension.iastate.edu/foodsafety/educators/tensteps.cfm?thepage=1&parent=2>

**NOTE:** For additional information on proper storage temperatures and handling, please visit:

[http://www.fns.usda.gov/fdd/programs/dod/DoD\\_Training\\_Prg-StorageFFV-071405.pdf](http://www.fns.usda.gov/fdd/programs/dod/DoD_Training_Prg-StorageFFV-071405.pdf)

The final quiz of this training module covers strategies to determine if produce items are good for consumption or if they should be discarded in the compost pile. Students will be quizzed over good storage practices, such as, “first in, first out,” and what the storage area should look like before placing product in its designated

location. Print the quizzes for students and pause the module until all students have finished with the quiz. Below are the answers for the final quiz.

#### Quiz 4

Quiz questions for elementary module: QUIZ 4

- 1) What should we do if rotting or damaged fruits and vegetables are found?
  - a. Save them and eat them anyway.
  - b. Feed them to pets or animals that are around the garden.
  - c. Separate them from good produce and add them to a compost pile.
  - d. None of the above.

Answer: If rotten produce is found, it should be set aside and added to a compost for later use. Damaged produce should NOT be saved for eating because it could have harmful microorganisms, in addition to undesired tastes. Rotting fruits and vegetables should not be fed to pets or animals around the garden because the animals could get contaminated and transfer those hazards to the garden soil or produce if exposed to it at a later time.

- 2) What should NOT be done with most fruits and vegetables before storing them?
  - a. Let them sit out for a few hours before storing them.
  - b. Place by rotting fruits and vegetables so everything is close together.
  - c. Put them in storage before cleaning.
  - d. All of the above.

Answer: All of the above are measures that should not be taken when storing produce items. If produce is allowed to sit out for hours before storage, contamination is more likely to occur. Cross-contamination is more likely to occur if rotting produce is placed next to the good fruits and vegetables. It is important to clean the produce before it is stored to remove any surface microorganisms or chemicals that may have been present from the garden.

- 3) What other surfaces need to be kept clean to keep fruits and vegetables safe?
  - a. Counter tops.
  - b. Cutting Boards.
  - c. Refrigerator shelves for refrigerated fruits and vegetables.
  - d. All of the above.

Answer: All of the above surfaces need to be kept clean to maintain the safety of fruits and vegetables. Counter tops and cutting boards should be washed prior to and after rinsing produce to reduce the chances of cross contamination from fomites or other possible contaminants.

- 4) After washing fruits and vegetables after storage, how should they be dried?
- a. Rub them with a reusable cloth towel.
  - b. Air-dry or blot the produce with paper towels.
  - c. Sun dry the produce items and wipe with a cloth towel.
  - d. Any of the above drying methods are preferred.

Answer: Both air-drying and blotting methods are acceptable after washing produce. They should not be rubbed with a reusable cloth towel. After numerous uses, reusable towels can pick up harmful microorganisms and become contaminated. It is important to use one-use paper towels if possible.

- 5) Throughout this video we have talked about several things that help us stay safe while working in the garden. Which of the following is not a way to stay safe?
- a. Wearing gloves
  - b. Washing our hands, the produce, and anything that comes in contact with them
  - c. Not using garden tools as toys.
  - d. Wearing sandals.

Answer: The goal of this training is to make sure we are aware of the different safety hazards associated with fresh produce production and distribution. All of the above examples show ways to minimize food safety risks, except for wearing sandals. Sandals can increase physical and biological risks. We could encounter sharp objects in the garden, which could cause physical pain if we touch them with our bare feet. Also, our feet may contain harmful pathogens, which could cross-contaminate the soil or fresh produce when we come in direct contact with it.

- 6) What will fruits and vegetables look like that are good for eating?
- a. Ripe and free from blemishes.
  - b. Rotting.
  - c. Spotted and cracked.
  - d. None of the above.

Answer: Fruits and vegetables that are good for eating will be fully ripe and have minimal to no blemishes. Bad produce that should not be eaten will be rotting, have spots over the surface, and could have cracks in the skin layer.

- 7) Why do we have to remove bad produce from the garden?
- a. To make sure we are providing a healthy product
  - b. To hide our failures
  - c. To keep the other produce from spoiling
  - d. Both A and C

Answer: We have to make sure to provide healthy products, as well as make sure to prevent additional spoilage from the produce that is currently growing in the garden.

- 8) What parts of the produce could show damage?
- a. The skin
  - b. The inside
  - c. The leaves
  - d. All of the above

Answer: When evaluating our fresh produce, we are only able to see the surface. We cannot see the inside of the produce item. Similarly, we will be able to see if there is damage to the leaves, but this is not part of our product we are providing for consumption. By evaluating the skin, we can confirm if there is damage to the produce prior to post-harvest practices.

- 9) Why are fruits and vegetables washed before eating them?
- a. To remove any additional dirt or debris that may be present on the fruit or vegetable after picking.
  - b. To remove chemicals that may still be present on the fruits or vegetables.
  - c. To remove potentially harmful microorganisms that could still be present on the fruits and vegetables.
  - d. All of the above.

Answer: All of the above are reasons that produce is washed before being eaten. By rinsing after storage, any additional dirt or debris will be removed. Washing produce before storage will also reduce chemical and microbial hazards. If the produce was sprayed with any pesticides or herbicides before being picked, they could still be on the surface of the fruit or vegetable. Rinsing will reduce the likelihood of any potential chemicals that are on the surface of the produce. It will also remove any harmful microorganisms that were still on the surface after storage.

10) How will you know where fruits and vegetables should be stored?

- a. Guess.
- b. Ask your friend.
- c. Ask your teacher.
- d. Don't bother, just leave fruits and vegetables in storage bins next to the garden.

Answer: It is important to ask your teacher where to store produce. Do NOT guess where to put it. Some produce requires refrigeration temperatures for storage, while other fruits and vegetables require room temperature conditions. Your teacher will have information on where to put the produce to make sure it stays as safe as possible until eaten at a later time.

### Script of Online Module:

Below is the script for the video. It will enable you to follow along and determine when to stop the video if you feel extra emphasis is needed at any point in the presentation. If students have questions throughout the presentation, the script will also help prepare you for any potential concerns or misunderstandings. By reading the script prior to showing the module to the students, you will be able to deliver this module however you feel necessary.

Welcome students! Do you like to eat fruits and vegetables? Fruits and vegetables, or garden produce, make us healthy and strong! Today, we are going to talk about how we can safely grow produce in our garden. There are some things that can affect produce and make us sick after we eat it. Today we are going to talk about what we can do to make sure our fruits and vegetables are clean and safe. We will be doing a few activities and also taking a few short quizzes to make sure we understand the important things we can do to help ourselves and keep others safe.

Even if we don't always feel like eating fruits and vegetables, we need to remember they are important for our nutrition. They make us strong and keep us healthy. Apples, bananas, strawberries, broccoli, carrots and tomatoes are just some of the fruits and vegetables that we can grow right in our own garden that will make us stronger. By eating more fruits and vegetables and eating less candy or fatty foods, we can lower the chances of getting different types of diseases when we get older. We need to start eating these now to keep us healthy for many years.

So how important are fruits and vegetables? This diagram is called the My Plate. It shows us how many fruits and vegetables we should eat at every meal. The red and green sections of the plate are for produce. You can see they make up half of the total plate! The amount of fruits and vegetables we are supposed to eat depend on your age, your physical activity, and if you are a boy or a girl. The older you are, the

more of these you should eat. The more physically active you are, the more energy you need every day.

Even though they are good for us, fruits and vegetables can make us sick if we don't grow and handle them properly. People get sick when produce isn't cleaned the right way. People also get sick when they eat fruits and vegetables that have harmful things on them. Before eating fruits and vegetables, we have to make sure to clean them well and remove anything that is on the outside of the produce.

We are going to take a short 10-question quiz now. It will cover why fruits and vegetables are important for us, what foods we should eat more of and, which ones we should stay away from. It will also ask why we are learning about garden safety.

There are different ways we can get sick or hurt if we don't work with food the right way. There may be bugs on the fruits and vegetables. These bugs are very small. We can't even see them with our bare eyes! To see these bugs, we would need a strong microscope. Even though we can't see them on the produce, it doesn't mean that they aren't there. We call these bugs "microorganisms." We use the word "micro" because that means very small. And we use the word "organism" because that word means living. So, microorganism is just a fancy way to describe them as small living things. Most microorganisms are actually good for us, but there are three main types that are harmful. The first type is called bacteria. Bacteria are very small living creatures that can live just about anywhere. In the garden, they can be in the soil, on the skins of fruits and vegetables, in the water, or even on the tools we use. We have to make sure to clean the fruits well so the bad bugs aren't on our fruits and vegetables. A few examples of bad bacteria that we might find in the garden are: *E. coli*, *Listeria monocytogenes*, and *Salmonella*. All of these bacteria can make us sick and affect us in different ways.

Another type of microorganism we have to watch out for is called a virus. Viruses are similar to bacteria, but they are even smaller. An example of a common type of virus is called Norovirus. Norovirus can be spread throughout the garden by not washing our hands.

The last type of microorganism is called a parasite. Parasites are larger than bacteria and viruses, but we still can't see them with our eyes. When working in the garden, parasites can be in the soil. One type of parasite that can make us sick is called *Toxoplasma gondii*. This parasite is also associated with cat litter.

We need to remember that all three of these types of bad bugs can be found naturally in our garden, so we have to be sure to take safety measures so we don't eat them and get sick.

Many people might eat the food from our garden. When working around food we have to think about our immune systems. Our immune system is the part of our body that helps us fight off bad microorganisms. However, some people have stronger immune systems than others. Someone with a weak immune system might not be able to fight off the bad microorganisms as well as those with a very strong

immune system. It is VERY important that we make sure our fruits and vegetables are clean and safe for everybody who eats them.

When we work in the garden, we also have to think about chemicals that may be applied on the crops to protect them from insects, weeds, and disease-causing organisms. Chemicals can be a very helpful tool in the garden. However, if we don't use them correctly, they can make us sick. While chemicals are a helpful tool, they are not required to produce a healthy crop. If chemicals are used, they must be applied according to the label on the container, and should always be applied by an adult. Chemicals should be stored in a locked storage area, and we need to make sure to use caution when around them.

The final thing we should be aware of and avoid are sharp objects that might be in the garden such as broken glass, sharp sticks, stones, rocks, and metal pieces. It's important to protect ourselves from these items by wearing gloves while working in the garden. If you see sharp objects, make sure to contact a teacher or an adult so they can get rid of them. DO NOT try to remove these items from the garden by yourself.

Also, remember garden tools are not toys and some can be sharp and dangerous if not handled correctly. The only time you should use these tools is while gardening.

Now we are now going to take a quick quiz about the different things we learned that could make us sick or hurt while we are in the garden. This quiz will have ten questions. See if you can remember all of the important steps you need to know when identifying dangers in the garden. Good luck!

Welcome back! We just finished talking about things that might hurt us or make us sick in the garden. Now we are going to talk about what we can do to prevent this from happening. There are many ways to make sure our fruits and vegetables are safe to eat, like preventing microorganisms from contaminating our garden crops.

We need to make sure microorganisms aren't on our fruits and vegetables when we harvest them from the garden. To grow fruits and vegetables we have to water the plants. Water helps the plants grow and produce the crop.

If we are watering the garden with a hose, we have to make sure NOT to drink out of the hose. We can have bugs that make people sick in our mouth. Some of the might come out of our mouth with the water, and spread the bugs to the fruits and vegetables, which can make other people very sick.

Microorganisms can also get on fruits and vegetables from animals. We have to make sure to keep all animals out of the garden as much as possible because they might poop in the garden. Many microorganisms from animals' poop can get on the fruits and vegetables and make them unsafe. We also have to remember that many animals can pick up diseases from other places too. If an animal with a disease gets into the garden, it can spread some of the disease to a fruit or vegetable that a person could eat later.



We can also contaminate fruits and vegetables by forgetting to wash our hands. Our hands often have microorganisms on them from other things that we touch. This can make people sick.

We need to wash our hands after going to the bathroom to keep the food and ourselves clean and healthy. We also need to wash our hands at other times when they are dirty. This could be after playing outside or after touching animals. It is also very important to wash our hands when we are done touching the fruits and vegetables. If the produce has microorganisms on it, we could accidentally eat them if we put our hands in our mouth, like biting our nails. This could make us sick.

When we wash our hands, we need to make sure to do it the right way. To wash our hands correctly, first, get your hands wet with warm or hot water. Then, put some soap on your hands. Make sure to rub your hands together for at least 10-15 seconds, which is about the time it will take us to sing, "happy birthday." Then, you need to clean in between your fingers and scrub under your fingernails, which is a great place for microorganisms to hide. After you have cleaned your hands and wrists, rinse them one more time under warm running water. This will get all of the extra soap off of your hands. The last thing to do is to dry them with a paper towel. By following this six step process, you will have very clean hands, and will get rid of the microorganisms that could be on them.

Now we are going to do a fun activity where we practice washing our hands the right way! We are going to put glowing liquid on our hands that we will be able to see under a special light. Look at the way the liquid glows when our hands are placed underneath these lights. Then, go to a sink and practice washing your hands with the six-step process to see if you washed your hands well enough. After drying your hands on the paper towel, put your hands back under the special light to see if you removed everything, so they no longer glow. Good luck!

Great job with washing your hands! It looks like we are doing all of the right things to prevent us from spreading microorganisms when we handle garden produce. It's now time for another activity. We are going to look at a few different pictures and see if we need to wash our hands after that specific daily activity. Please stop or pause this training video until the activity has been completed.

It's important to remember to wash our hands after all of these activities. We need to wash our hands before handling fruits and vegetables regardless of what we are doing so that we don't get bad microorganisms on the produce from other things we touch during the day.

When we work in the garden, we use many different types of chemicals. Some keep insects and animals away; we call these pesticides. We also use chemicals to kill weeds, and we call these herbicides. We also use chemicals to keep gardening tools and other objects clean, which we call sanitizers. All of these chemicals are very helpful to us. However, some of these chemicals can make us sick if we don't use them the right way. Chemicals need to be kept away from fruits and vegetables. If

we see chemical containers in the garden, we have to make sure to tell the teacher or adult about them, and not try and pick them up by ourselves.

We are now going to talk about sharp or dangerous objects that we might see in the garden that can hurt us when we were in the garden, or that could be in or on the fruits and vegetables when we pick them out of the garden.

Gardening tools are useful, but can be dangerous. When using gardening tools, we have to make sure to only use them the way they are supposed to be used. Set the tools down with the sharp parts down, against the ground so people don't get hurt or fall on them. Another thing we can do is give the gardening tools to the teacher to put in a safe place.

When gardening, there are many sharp or dangerous objects that can hurt us while we work. The objects can also be on the fruits and vegetables when we pick them. We may pick up a fruit or vegetable that has broken glass or a sharp stick in it that can hurt us if we touch it in the wrong place. Gardening tools in particular can be dangerous. Be sure to only use the tools the way they were meant to be used. When you are finished using the tools, give them to a teacher or adult to put away, or be sure to set them with the sharp parts pointed toward the ground, so others don't fall or trip over them.

Fences surrounding the garden are another physical objects that should be treated with care. Fences are not meant to be a jungle gym or a toy, so we shouldn't touch or climb on them. We should also wear clothes that protect us while we work in the garden. An example of this would be to wear close-toed or tennis shoes to protect our feet, instead of sandals or going barefoot.

Now let's take another quiz. This quiz will cover the different types of things we can do to ensure we don't get sick or hurt when working in the garden. It will cover bad microorganisms, chemicals used on fruits and vegetables, and physical objects that can hurt us when working in the garden.

Welcome back everyone! We have talked about the bad things that can happen in the garden, and what we can do to prevent them. Now, lets talk about what to look for when picking fruits and vegetables. After that, we will talk about how to keep the produce safe and tasty so everyone can enjoy.

When picking fruits and vegetables, look for produce that looks great to eat and also for produce that looks bad. Good produce will be full sized and ripe in color. They will not have any soft spots or bug bites on them. Bad produce will have spots, cracks, and discolored areas. Bad produce won't look good to eat. Even though we wont use the bad fruits and vegetables, we need to remove them from the garden and place them in a compost pile or in the garbage. Bad produce spoils quickly and may cause other fruits and vegetables from the garden to spoil as well. Your teacher will be able to help you tell the difference between good and bad produce.

To pick out the differences between good and bad fruits and vegetables in the garden, we will have to be detectives! We need to look closely and see if anything on the surface of the fruit or vegetable that doesn't look normal or right. Do you think you can be a good detective?

Let's test your detective abilities. We are going to look at some pictures of different fruits and vegetable. We need your help to tell the difference between good produce and bad produce we should send to the compost pile or to the garbage. Good luck detectives! Please stop or pause this training video until the activity has been completed.

Good job everyone! As you can see, only the cucumber was a good piece of produce. All the other produce in the pictures are bad produce. The apple shows a different color on the backside that might be mold; the corn is rotten and should not be eaten. The avocado and tomato both have weird colors and also show that they are rotten. Since all of these fruits and vegetables have holes in the skin, it is possible bad microorganisms can enter the produce and make us sick if we eat them.

Now that we know what fruits and vegetables are safe for us to eat, we need to know how to store them so they stay safe and still taste good. We must always wash and rinse our fruits and vegetables before serving or eating them. Some fruits and vegetables are best stored in the refrigerator, while others need to be stored at room temperature. As you know, we need to make sure that we clean the fruits and vegetables we pick and also clean the areas where food will be stored. By cleaning the food and storage areas, we can reduce the chances of having unsafe fruits and vegetables. Even though we washed the fruits and vegetables before we stored them, we should wash them again before we eat them to ensure they are safe.

Now let's take the final quiz over what we should look for when picking fruits and vegetables, how to tell good fruits and vegetables from bad, and what we should do make sure fruits and vegetables are cleaned and stored the right way.

**Risk Management:**

As illustrated throughout the teaching manual and learning module itself, there are many different hazards that may be present when working in school or community gardens. Before beginning our garden program, make sure you have a fully stocked first aid kit readily available. The first aid kit should include a minimum of: Bandages, adhesive cloth tape, antibiotic ointment packs, aspirin, 2 pairs of latex gloves, scissors, sterile gauze pads, and tweezers. If any of these materials are used, be sure to restock the first aid kit for future use. In addition to having a first kit, it is important to keep medical phone numbers on hand if needed. Have your local hospital number on hand and ready if needed. Make sure to also have the poison control center phone number ready in case of any chemical ingestion. Lastly, have phone numbers for each student's parent or guardian readily available, or alert the school office. This will allow for parents or guardians to be quickly contacted should there be an incident.

## **Additional exercises:**

In addition to the exercises included in the module, there are a few other hands-on activities you can choose have the students learn. These exercises can be accessed from the “Activities” tab on the right side of the module.

### **Additional Activity #1: Cleaning our Produce**

Educational requirements for Activity #1:

Students should have knowledge of:

- General biology concepts.
- Proper sink or hose usage.
- The proper storage location for fresh produce.

Activity #1 tools needed:

- Potable water source – running water from a sink or hose.
- Disposable paper towels.
- Produce item that is to be cleaned.
- Appropriate/clean produce storage location.

In this activity, we will focus on produce that has already been harvested. Once harvested, the produce must be rinsed appropriately, and stored in a clean, storage location with appropriate temperature for that produce item.

For this activity, have students standing at a sink or hose that has clean water (If not available, present the material to the students so they can see and understand how produce must be properly rinsed). Have the students take the produce item, and rinse it under the running water, washing the surface of the produce item clean. Once rinsed, have students turn off the water, drain excess water, and blot the produce with a disposable paper towel. When the produce is dried, have students place the produce in the appropriate storage area (refrigerated produce should be placed in a clean container or on a clear surface in a clean refrigerator while room temperature produce should be placed in a designated area that is secure).

### **Additional Activity #2: Find the Hazards in the garden**

Educational requirements for Activity #2:

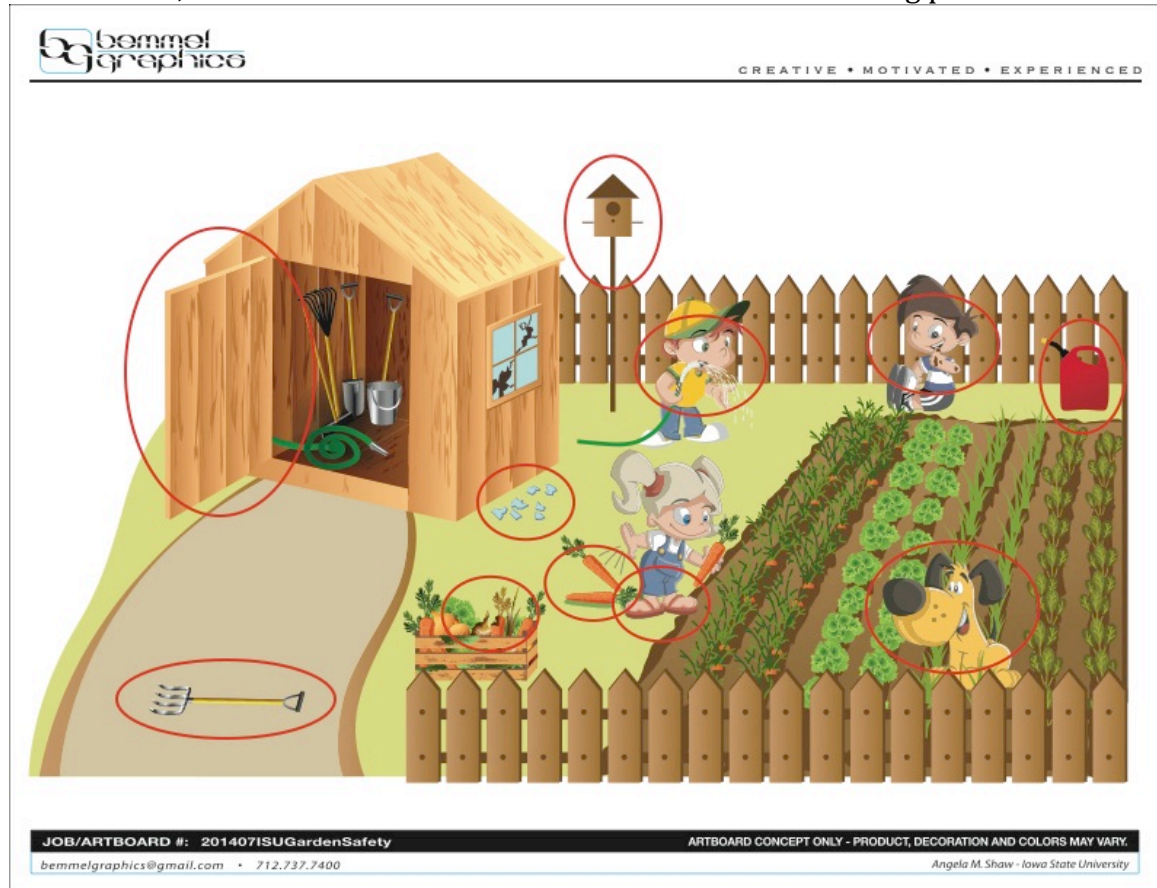
Students should have knowledge of:

- General biology concepts.
- Basic chemical application.
- Common physical hazards.
- Location and familiarity with garden.
- Common gardening tools/chemicals.

Activity #2 tools needed:

- Printer to print off and copy the worksheets.
- Pen or pencil for each student.

In this activity, students will have to evaluate biological, chemical, and physical hazards that are likely to be present in a garden setting. This activity will be a printout that is located in the “Activities” tab to the right of the module. Below is the answer key to all of the hazards that are present, with an explanation of why they are a hazard, in addition to how to eliminate the hazard from being present.



Hazards in the garden:

- Shed door left open.
- Garden tool placed in an inappropriate location.
- Broken glass from tool shed dispersed on the ground in the garden.
- Dog allowed to walk around the garden.
- Chemical container left in the back corner of the garden.
- Rotten produce picked and placed in the harvest bin with good produce.
- Child holding hose and drinking from it.
- Child in the soil putting soiled hands in mouth.
- Fresh Produce placed on ground.
- Having a birdhouse in the garden.

### **Additional Activity #3: What Would You Do?**

Educational requirements for Activity #3:

Students should have knowledge of:

- General biology concepts.
- Basic chemical concepts.
- Common physical contamination.
- Situational critical thinking.

Activity #3 tools needed:

- A printer to print off case studies.
- Pen or pencil for each student.

This exercise will be available in the “Activities” tab to the right side of the module. In this activity, students will receive three short case studies of people working in the garden. Each study will emphasize different areas of improper garden practices. After reading each study, students will be expected to identify all of the hazards in each case study, explain why it is a hazard, and what the person in the case study should have done to eliminate the hazard from arising. Upon completion of the third case study, a majority of the most common hazards will have been addressed, and students will have safety concepts reinforced before entering the school or community garden.

Below is the answer key for all of the hazards in each of the case studies provided.

### **ANSWER KEY: WHAT WOULD YOU DO? Case Study #1:**

Brian washed his hands with soap and water before going out to pick fruits and vegetables. He tied his shoelaces tightly, and went into the garden to pick the produce.

Brian saw some gardening tools outside of the garden, so he decided to use them on some of the produce items as he went around collecting fruits and vegetables. When finished with the tools, Brian set them down in the garden and went back to picking.

After picking produce for some time, Brian heard the class puppy, Scrappy, barking at the gate of the garden. Feeling bad for Scrappy, Brian opened the gate to the garden to let Scrappy walk around the garden while he picked the fruits and vegetables.

When Brian finished picking the fruits and vegetables, he left the basket by the entrance to the garden and went inside to wash his hands with soap and water.

#### **1. What did Brian do wrong?**

--- Brian left the gardening tools in the garden. If not removed after using, these can become physical hazards because other people could step on them.

---Brian let the class puppy, Scrappy, into the garden. Do not let animals into the garden, because they can poop on the produce or spread disease to it. Animals also carry harmful bacteria that can make the produce unsafe to eat.

---Brian left the basket of fruits and vegetables by the entrance to the garden. These were not given to the teacher to properly store.

## 2. What can YOU do to avoid these problems?

--- When using gardening tools, always make sure to place them in a designated storage location to reduce the chances of injury to others. These tools should be properly cleaned before placed in their designated storage location to reduce the hazards of later use.

--- Keep wild animals and pets out of the garden as much as possible to reduce the chances of contaminating the produce, plants, or soil.

--- Make sure to give the produce to the teacher so it can be properly stored. If inappropriately stored, the produce will be more likely to rot or be unacceptable.

### **ANSWER KEY: WHAT WOULD YOU DO? Case Study #2:**

Little Susie rinsed her hands thoroughly with soap and water before going out to the garden to pick fruits and vegetables. Susie entered the garden wearing her sandals and her basket and began picking produce that was ready. As she was harvesting, Susie saw a broken glass bottle in the garden. She safely stepped over it and continued picking the produce.

After awhile of picking produce, Susie was feeling very thirsty. She looked around the garden and saw the garden hose. She went over to it, turned it on, and took a quick drink from the hose.

When Susie finished in the garden, she gave the produce to her teacher to put in a safe place. She then washed her hands under the sink for two seconds before going back to class.

## 1. What did Susie do wrong?

---Susie entered the garden wearing sandals. Sandals should not be worn because of physical hazards that could be present in the garden.

---Susie only stepped over the broken glass that was in the garden. Susie should not pick it up because of potential harm, but she should also not completely ignore it.

---Susie drank out of the garden hose. NEVER drink from the garden hose. Susie could have potentially harmful microorganisms in her mouth, and they could travel from her mouth to the soil or produce through the stream of water and make the produce unsafe.

---Susie only washed her hands for 2 seconds under the sink. It is important to wash hands thoroughly with soap to clean the hard-to-reach areas on her hands



and remove any potentially harmful microorganisms that got on her from picking produce.

## 2. What can YOU do to avoid these problems?

--- Bring a pair of close-toed shoes to school if you are wearing sandals. Before entering the garden, change into the shoes to avoid any sharp objects (broken glass, sharp plastic or stones). Shoes should be kept on until leaving the garden area.

--- Inform the teacher or adult of the broken glass when it is seen. The teacher or adult will be able to remove the broken glass safely so people who go into the garden later are not cut by the broken glass.

--- Do NOT drink from the hose. Bring a water bottle out to the garden with you and set it by the garden entrance or go visit a nearby drinking fountain. When thirsty, leave the garden, take a quick drink, and then go back to picking produce.

--- When washing hands, make sure to lather them with soap for at least 10-15 seconds, or how long it takes to sing, "Happy Birthday." After lathering, rinse the rest of the soap off and wash hands with a single-use, disposable paper towel.

## REFERENCES:

For further information on any of the general information mentioned in the teaching manual or in the module itself, click the online links listed below. These links provide additional information on potential biological, chemical, and physical hazards that may arise when working in the garden, and what additional measures you can take to prevent all of these hazards from arising in your community or school garden.

General comprehensive resources for garden food safety:

- <http://www.extension.iastate.edu/hrim/localfoods>
- <http://extension.psu.edu/food/safety/farm/gaps>
- [http://www.schoolnutrition.org/uploadedFiles/School\\_Nutrition/104\\_CareerEducation/ContinuingEducation/Webinar\\_Wednesdays/GAPs%20School%20Gardens-11.3.11%20FINAL%20UPDATED.pdf?n=8068](http://www.schoolnutrition.org/uploadedFiles/School_Nutrition/104_CareerEducation/ContinuingEducation/Webinar_Wednesdays/GAPs%20School%20Gardens-11.3.11%20FINAL%20UPDATED.pdf?n=8068)
- [http://www.schoolnutrition.org/uploadedFiles/School\\_Nutrition/104\\_CareerEducation/ProfessionalDevelopment/Certification/Cerification\\_Documents/Food%20Safety%20Tips%20for%20School%20Gardens.pdf?n=7984](http://www.schoolnutrition.org/uploadedFiles/School_Nutrition/104_CareerEducation/ProfessionalDevelopment/Certification/Cerification_Documents/Food%20Safety%20Tips%20for%20School%20Gardens.pdf?n=7984)
- [http://www.wafarmtoschool.org/Content/Documents/School\\_Gardens\\_Food\\_Safety\\_Tips\\_-\\_Maryland\\_Extension.pdf](http://www.wafarmtoschool.org/Content/Documents/School_Gardens_Food_Safety_Tips_-_Maryland_Extension.pdf)
- [http://www.wafarmtoschool.org/Content/Documents/Serving\\_Foods\\_Grown\\_in\\_School\\_Gardens.pdf](http://www.wafarmtoschool.org/Content/Documents/Serving_Foods_Grown_in_School_Gardens.pdf)
- <http://www.sde.ct.gov/sde/LIB/sde/pdf/DEPS/Nutrition/OPmemos/10/5stepsOM1010.pdf>
- <http://www.cde.ca.gov/ls/nu/he/gardensafety.asp>
- <http://ucfoodsafety.ucdavis.edu/files/157441.pdf>
- <http://wwwnc.cdc.gov/eid/article/19/3/pdfs/11-1866.pdf>
- <http://agrilifefoodsafety.tamu.edu/files/2011/03/Pre-Harvest-and-Harvest-Food-Safety.pdf>
- [http://s3.esoft.com.mx/esofthands/include/upload\\_files/4/Archivos/7%20Contamination%20hazards%20in%20fresh%20fruits%20and%20vegetables.pdf](http://s3.esoft.com.mx/esofthands/include/upload_files/4/Archivos/7%20Contamination%20hazards%20in%20fresh%20fruits%20and%20vegetables.pdf)
- <http://www.maricopa.gov/publichealth/Services/Nutrition/Garden/pdf/minimizing-microbial-food-safety-hazards-in-the-school-garden.pdf>
- [http://pubs.ext.vt.edu/FST/FST-60/FST-60\\_PDF.pdf](http://pubs.ext.vt.edu/FST/FST-60/FST-60_PDF.pdf)
- <http://ucanr.org/freepubs/docs/8366.pdf>

APPENDIX B: INSTRUCTOR MANUAL FOR UNIVERSITY MODULE

## On Farm Food Safety Manual: University Farms



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## Glossary/Vocabulary terms:

**Biosolids** – Organic material that is nutrient rich that can be used as a supplement for plant growth.

**Bacteria** – Small, single- celled organisms that are able to replicate with other bacteria; they can grow just about anywhere, including soil, water, and in/on food products.

**Pesticide** – A chemical substance that is used to destroy or remove insect or animal damage to plants.

**Herbicide** – A chemical substance that is used to prevent weed growth or kill specific weeds.

**Sanitizer** – A substance that is applied to surfaces to destroy or kill any microorganisms that are living on it.

**Harvest** – The process or period of gathering crops; the action of pulling crops from the garden and preparing them for further processing.

**Traceability** – The practice of maintaining record of where products have been shipped or moved to; allows manufacturers to pinpoint where an outbreak may occur.

**Regulations** – laws that are put in place to protect individuals that are more likely to become sick or ill from contaminated products; These can be local, statewide, or national laws.

**Immune-compromised** – having an impaired immune system; being more susceptible to illness than other individuals because the body is unable to combat harmful components that enter the body.

**Municipal Water** – Water that has been chemically treated by a company; the treatment done by the company eliminates harmful microorganisms, making the water safe for ingestion.

**Compost** – Decomposed organic matter that is applied to garden soil to improve soil tilth and water nutrient retention.

**Virus** – A non-living particle that is smaller than a bacteria; It is unable to reproduce without a living host (a living organism that supplies what is lacking).

**Parasite** – An organisms that lives in or on another organisms (its host); It benefits and thrives by taking nutrients from the host.

**GAPs** – Good Agricultural Practices. These practices are specific to agriculture that must be followed to make sure food is safe and wholesome for future produce processing steps.

**GMPs** – Abbreviation for Good Manufacturing Practices. These practices are taken during the manufacturing of produce to help ensure the quality and safety of the item being produced.

**SSOPs** – Abbreviation for Standard Sanitation Operating Procedures. These are developed by the specific company, and are put in place to maintain cleanliness of the equipment, ensure consistent compliance with best sanitation practice, and maintain order in the facility.

**SOPs** - Abbreviation for Standard Operating Procedures. These are descriptions for designated tasks that must be carried out in a specific order following listed

protocol; they work in conjunction to GMPs to provide a foundation for the organization's HACCP plan.

**HACCP** – Abbreviation for Hazard Analysis and Critical Control Points. This program is a systematic approach that combines GAPs, GMPs, SSOPs, and SOPs in development of an organization's food safety plan. The overall goal is to prevent physical, chemical, and biological hazards from entering any part of food processing.

**Fecal Coliforms** – A specific type of microorganism that is an indicator of fecal contamination.

**Potable** – water that is safe to drink.

**Cross-Contamination** – The transfer of harmful microorganisms, chemicals, or physical hazards from a contaminated product to a surface that was originally safe.

**Pathogen** – a microorganism that can cause disease.

**Fomite** - A non-living object that has the ability to transmit infectious agents from one source to another (examples: Doorknobs, toys, cellular phones).

**EPA** – Abbreviation for Environmental Protection Agency. This is a federal organization that helps reduce pollution and protect the environment.

**"Farm-to-Fork"** – A phrase used to describe processing of food from pre-harvest on the farm through consumer purchase at the grocery store.

**"First in, First out"** – A phrase used to describe rotation of inventory in storage. Older items in storage are removed and used first.

**State Educational Requirements:**

Some material in this training module may be too complex or detailed for employees that have not been exposed to it previously. For best retention and understanding of the module:

- Employees should be able to analyze and interpret scientific information.
- Employees should be able to understand concepts and relationships in life science.
- Employees should have a basic understanding of environmental interactions and adaption.
- Employees should be knowledgeable of introductory/mid range biology terms and concepts (general knowledge of small living organisms or mild vocabulary terms).
- Employees should be aware of general handwashing practices (general hygienic practices).
- Employees should have basic problem solving abilities and be able to work in small groups.

**Tools Needed:**

To have a successful experience with this online training module, you will need these tools and devices:

- A lecture computer or computers for each student who has accessing to the Internet.
- Functioning speakers on the computer(s) or additional audio equipment.
- Access to a printer for the quizzes that are to be administered throughout the module.
- Pencils for interactive exercises and quizzes throughout.



## Getting Started:

Follow these steps to successfully begin running the online module:

- Acquire a computer or classroom of computers with Internet capability and sound. Turn the computer(s) on.
- Once the computer(s) are ready, start up the Internet.
- When the Internet is ready, go to <http://www.safeproduce.cals.iastate.edu/university/>, the website that the module is located at.
- Once you have accessed the link, click the play icon in the bottom right corner of the screen to start running the module.
- To the right of the screen you will see three different tabs labeled, “Quizzes, Activities, and references.” When it comes time to take the quizzes or do additional activities, click these links for additional information. For further information on garden safety, click the, “References” tab.

**Outcomes:**

- Upon completing this learning module in its entirety, students will be able to identify various biological, chemical, and physical hazards found during the preparation and production of produce items.
- After watching this training module, students will know what must be done to minimize biological, chemical, and physical hazards.
- Workers will learn about information included in a food safety plan for produce processing, from Good Agricultural Practices (GAPs), to Standard Operating Procedures (SOPs), and Sanitation standard Operating Procedures (SSOPs).
- Workers will become familiar with the most common microorganisms found in produce items, different types of microorganisms, and what must be done to minimize contamination.
- Workers will learn how to properly maintain records for produce items, including all pertinent information that must be included on data sheets.
- After watching this module, workers will demonstrate understanding of proper hygiene practices to use before, during and after handling produce.
- Workers will identify basic food regulations at federal, state, and local levels and key concepts of the Food Safety and Modernization Act (FSMA), related to fresh produce.

**Benefits:**

Added benefits that workers will know, do or say as a result of this learning module are:

- Critical thinking by completing multiple choice quizzes and activities.
- Minimizing physical hazards associated with produce processing.
- Minimizing chemical hazards associated with produce processing.
- Basic understanding on how to develop a HACCP plan through GAPs, GMPs, SSOPs, and SOPs associated with produce.
- Examples of different microbial, chemical, and physical hazards during preharvest steps of produce processing and how to reduce/prevent produce contamination.
- Examples of different microbial, chemical, and physical hazards during postharvest steps or produce processing and how to reduce/prevent produce contamination.
- Knowledge on how to manage and update important record keeping information.
- How to perform proper hygienic practices; such as washing hands, cleaning work garments, understanding of cross-contamination, and proper restroom usage.
- Knowledge on the different levels of food regulations, why they are implemented, and examples for each level of regulation.
- Introduction to the Food Safety Modernization Act.
- Actively engage with other workers and instructors to understand and retain concepts throughout module.

## Overall outline of online module:

This training manual outlines the module, slide by slide with additional information for you, the instructor. This overview will help you answer questions from your workers.

This section is introductory and allows the workers/students an overview of what this online training module will focus on. As the module gets more complex, additional information will be provided in this teaching manual to inform you on areas where potential questions may arise. There is also a reference section at the end of this teaching manual to provide you with additional information.

Next, the workers/students are informed on what the purpose of the online training module is, and what they can gain from listening to the presentation and actively participating in activities.

Workers/students will demonstrate knowledge of the information on the module by successfully completing four multiple-choice quizzes administered throughout the training. The next section informs the audience on the length, format and the purpose of each quiz. The four sections in the module address topics which the quizzes intertwined in the module address: introductory material, pre-harvest hazards and prevention strategies, postharvest hazards and prevention strategies, and proper hygienic practices and current regulations associated with produce processing.

After understanding the layout of the online training module, the workers learn why illness from produce related items is an important issue. The students should know that fresh vegetables and fruits/nuts were the implicated food in 45.9% of total foodborne illnesses reported over a 10-year period. This module includes the breakdown of each type of contamination on fresh fruits and vegetables (bacterial, chemical, parasitic, and viral) that led to the illness.

Students will learn different ways on how to reduce chances of foodborne illness occurrences. They will learn how to properly harvest produce and transport it safely to the cleaning and packaging location, how to handle the product properly after harvesting to minimize hazards and retain quality, and how to properly handle produce in order to minimize contamination risks. For more information refer to these.

### Foodborne illness resources:

- [www.iowafoodsafety.org](http://www.iowafoodsafety.org) – click on Education and Training and Safe Food Lessons
- <http://wwwnc.cdc.gov/eid/article/19/3/pdfs/11-1866.pdf>
- <http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/2006/ucm108780.htm>
- <http://www.foodsafety.gov/poisoning/risk>
- <http://www.cdc.gov/foodsafety/diseases/>

- <http://food.unl.edu/web/safety/poisoning>

Workers will next be introduced to the potential microbial hazards associated with produce production. A brief introduction on what a microorganism is and where microorganisms can be found is presented. After learning about general microorganisms, more detailed information about each type of harmful microorganism will be given. Bacteria will be the first type of microorganisms introduced.

A few of the bacteria implicated in food borne illness associated with improper production and handling of fruits and vegetables are *Escherichia coli* 0157:57, *Listeria monocytogenes*, and *Salmonella*. *E. coli* 0157:H7 is a big concern when working with produce because it is found in the soil and has a very low infectious dose, meaning it takes few cells to cause illness in consumers. Symptoms associated with *E. coli* are bloody diarrhea and abdominal cramps. For those that are immune-compromised, hemolytic uremic syndrome (HUS) may occur. HUS leads to death of red blood cells, and eventually results in kidney failure.

*Listeria monocytogenes* is another type of bacteria that can affect consumers in a negative way. Some symptoms of *Listeria monocytogenes* are: fever, muscle aches, stiff neck, loss of balance, convulsions, and/or diarrhea. *Listeria monocytogenes* is a serious risk for pregnant women. If ingested, *Listeria monocytogenes* has the ability to cross the placental barrier and lead to a miscarriage and stillbirth of the fetus.

*Salmonella* is another bacteria discussed. All strains of *Salmonella* are pathogenic to humans, but the illness severity depends on the species of *Salmonella*. Symptoms associated with *Salmonella* are bloody diarrhea, fever and/or abdominal cramps. These symptoms will typically occur 12 to 72 hours after ingestion of food in which high levels of the bacteria is present. It is more likely for serious illness to occur in the young, elderly, and immune-compromised if ingested.

It is important to remember that these are not the only disease causing bacteria or pathogens that could be present on produce items; there are many others that can be present and cause illness if produce isn't properly handled. Because fresh produce is frequently served raw, it does not receive a kill step through cooking. After these bacteria are discussed, trainees will be introduced to viruses and why they are of concern. One example of a virus that may be on produce items is Norovirus. Norovirus is one of the most common occurring microorganisms and is the virus implicated most frequently in reported outbreaks. This virus can be spread through cross-contamination or from food or water contaminated with fecal matter. Symptoms associated with Norovirus are diarrhea, vomiting, nausea and/or stomach pain. Additional symptoms may include fever, headache, or overall body aches. There are many viruses that can cause illness and are easily spread due to improper hygiene; this is just one example.

The last type of microorganism explained is parasites. One example of a parasite that could contaminate produce items is *Toxoplasma gondii*. This is a parasite that originates in cats, but can be transmitted from cats to humans through fecal contamination. Symptoms of *Toxoplasmosis* are similar to that of the common flu..

**Microbial hazard resources:**

- <http://www.extension.iastate.edu/foodsafety/lesson/l1/l1p1.html>
- <http://www.fda.gov/downloads/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/ProduceandPlanProducts/UCM169112.pdf>
- <http://www.maricopa.gov/publichealth/Services/Nutrition/Garden/pdf/minimizing-microbial-food-safety-hazards-in-the-school-garden.pdf>
- <http://www.cdc.gov>
- <http://digestive.niddk.nih.gov/ddiseases/pubs/bacteria/>

Physical hazards are introduced next. Examples of physical hazards that may be present in the field and cause harm if exposed to the worker will be given. All of these physical hazards will be explained in further detail in their section of the module.

The last type of hazard introduced is chemical. Much like the physical hazards, types of chemicals that may be used on the farm or in the garden will be identified with an explanation of why they are used. Further in the module, greater detail on these hazards at both pre and postharvest phases of production will be given.

This section provides organization of the content in the remainder of the module. Topics presented are different phases of produce production. The module is divided into different sections for user convenience and to allow for instructor management of time. All preharvest and postharvest risks and good worker practices are further explained in their designated sections of the module. Additional information on each risk is included in the instructor manual at that designated section.

The first quiz will now be administered. Please make sure to pause the module until all workers and students have completed the quiz. The purpose of this quiz is to test audience retention on the introductory material related to hazards associated with produce production. This quiz will focus on microbial hazards (where they can be and what types of microorganisms there are), physical hazards that may occur as part of production, and chemicals used in the process. Listed below are the answers to the quiz:

**Quiz questions for university module: Quiz 1**

1) Is this training a substitute for a Good Agricultural Practices workshop?

A) Yes, it is a substitute.

B) It counts for half of a Good Agricultural Practices workshop

C) No, it is not a substitute.

D) I'm not sure if this substitutes.

Answer: This training does emphasize important food safety issues related to fresh produce production and distribution, but does not provide as much information as a Good Agricultural Practices workshop does. This training was developed to inform farm workers on the basic food safety risks and risk prevention techniques to consider when working with fresh produce.

2) What are three types of hazards that fresh produce are exposed to?

A) Environmental, Manufacturing, and Employee

B) Biological, chemical, and physical

C) Plant, animal, and soil

D) None of the above

Answer: The three different types of hazards that fresh produce and fresh produce workers may be exposed to are biological, chemical, and physical hazards. Biological hazards include bacteria, viruses, and parasites. Chemical hazards include pesticides and naturally occurring toxins in the fresh produce. Physical hazards include objects that can cause physical harm (broken glass, hard plastic, stones).

3) The hazards presented in this training are found in which stage of production?

A) Growing

B) Harvesting

C) Post-Harvest

D) All of the above

Answer: This training emphasizes food safety hazards that can arise during growing, harvesting, and post harvest steps of fresh produce production. The training shows what hazards are associated in each step of produce production, and what prevention strategies can be used to reduce food safety risks in fresh produce.

4) What percent of reported foodborne illnesses were attributed to produce related items?

A) About 25%

B) About 50%

C) About 75%

D) About 100%

Answer: Almost 50% of foodborne illnesses are attributed to produce related items. The Centers for Disease Control and Prevention estimated that from 1998 to 2008, 46% of foodborne illnesses were caused to produce related items. These include fruits, vegetables, and nuts. A high percentage of illness has been caused by leafy greens and lettuce. Other produce items that have also caused foodborne illness include cantaloupe, tomatoes, and peppers.

5) About what is the typical size of a microorganism?

A) 0.1 millimeters

B) 1 nanometer

C) 1 millimeter

D) 1 micrometer

Answer: The typical size of a microorganism is around 0.1 millimeters. This is smaller than the eye can perceive, and can only be viewed under a microscope. These microorganisms can reside in the soil, water, or on the fresh produce itself.

6) Which of the following is a harmful bacteria if ingested by humans?

A) *Toxoplasma gondii*

B) *Listeria monocytogenes*

C) *Streptococcus thermophilus*

D) All of the above are harmful bacteria

Answer: A bacteria that can cause harm to humans if ingested is *Listeria monocytogenes*. Young, elderly, pregnant, and immune-compromised individuals are more at risk of illness if ingesting *L. monocytogenes*. *Toxoplasma gondii* can cause harm, but it is considered a parasite. *Streptococcus thermophilus* is a beneficial bacterium that is used in the production of yogurt that will not cause harm if ingested.

7) Which of the following is a common virus found on produce items?

A) Influenza virus

B) Tobacco Mosaic virus

C) Norovirus

D) West Nile virus



Answer: Norovirus is commonly found on produce items. It is the leading cause of illness from fresh produce. The mortality rate is lower for norovirus than other foodborne illnesses.

8) What is the main goal of this training?

- A) To teach new employees how to have a green thumb
- B) To inform workers about new policies
- C) To boost understanding about why safe practices are necessary
- D) None of the above

Answer: This training was developed to make sure farm workers are aware of food safety hazards associated with fresh produce, and why safe practices are necessary when working in direct contact with them.

9) Where can microorganisms reside?

- A) In the soil and organic matter
- B) In water
- C) In human hosts
- D) In all of the above

Answer: Microorganisms can reside in soil and organic matter, in water, and in human hosts. To reduce microbial food safety risks, we have to follow GAPs and Good Manufacturing Practices when working directly with fresh produce.

Following the quiz, the pre-harvest section of produce production is introduced. Slide 9 gives the audience a definition for pre-harvest and outlines the objectives for this specific section of the learning module.

The first concept of the pre-harvest section is about Good Agricultural Practices (also known as GAPs). GAPs are the basis of developing and implementing an effective food safety plan. This portion explains why GAPs are needed for produce food safety. It also outlines some of the benefits when implementing GAPs into the hazard prevention plan.

Workers need to understand that GAPs are recommendations that help improve quality and reduce safety risks with produce items. Because GAPs are focused on the agricultural aspect, they are mainly meant to emphasize soil, water, hands, and other surfaces the produce may come in contact with. The recommended GAPs will help us maintain “clean” soil, water, hands, and surfaces, which ultimately reduces the chance food borne illness will occur.

It is very important for students and workers to understand this next concept. It informs the workers on all of the components needed for a food safety plan to be successful. The script briefly explains each of the steps with an example at each

step. This instruction manual will outline each step in more detail in the event further explanation is needed. For additional information on GAPs, please refer to the references section of the training manual.

Once GAPs are implemented, workers need to understand what Good Manufacturing Practices (GMPs) are necessary for the processing that occurs. Examples of some GMPs include frequent inspections of the building or facility and equipment, monitoring of personnel working with the produce, regular and accurate record keeping, and proper labeling of products. Each of these examples will occur after the produce has been harvested.

Sanitation Standard Operating Procedures (SSOPs) and Standard Operating Procedures (SOPs) are specific practices that are implemented to make sure adequate cleaning is performed and guidelines are followed when working around food and handling the produce.

By implementing specific procedures and protocols in SSOP and SOP that include GAPs and GMPs, a decrease of all types of foodborne hazards will result.

#### **GAP, GMP, SSOP, SOP, and HACCP Resources:**

- <http://www.extension.iastate.edu/publications/pm1974a.pdf>
- <http://www.uky.edu/Ag/CDBREC/introsheets/gap.pdf>
- <http://www.fao.org/prods/gap/>
- <http://www.fda.gov/Cosmetics/GuidanceComplianceRegulatoryInformation/GoodManufacturingPracticeGMPGuidelinesInspectionChecklist/>
- <http://ucanr.edu/sites/GAP/newsletters/GMPs41394.pdf>

After being familiarized with the outline of a food safety plan, workers are introduced to the microbial hazards associated with pre-harvest produce items. This section introduces the different microbial hazards that may occur during the pre-harvest steps of produce processing. Each of the microbial hazards mentioned on this slide are explained in greater detail.

The first microbial hazard discussed in pre-harvest production is the use of water on the produce. Potential types of water sources and types of water that should and shouldn't be applied to produce are discussed. If untreated water is used, suggestions and examples are given in the module on what should be done to reduce hazardous compounds from reaching the product.

There are many different ways contaminated water can reach the produce item such as through chemical application, irrigation and employee practices. For chemical application, make sure that water mixed with chemicals is potable. An improper water source when irrigating has potential to contaminate the entire produce lot, therefore, a clean water source must be used when irrigating. Clean water must be made available for employees to wash their hands as unclean water may result in employees unintentionally cross-contaminating the produce with harmful microorganisms from their hands.

Additional ways water may become polluted or be a hazard is from chemicals or metals. If chemicals are improperly applied or overused, they can accumulate in certain areas when it rains. This can lead to even higher chemical concentrations, which can lead to a chemical hazard later in processing.

Some metals, such as arsenic, cadmium and lead can find their way into the atmosphere and then land on the produce when it rains. For this reason, it is very important to thoroughly rinse and wash most (Note that certain produce items should not be washed at all).

#### Water hazard resources:

- <http://www.cdc.gov/healthywater/other/agricultural/contamination.html>
- [http://www.chewonki.org/cleanwater/water\\_pollution.asp](http://www.chewonki.org/cleanwater/water_pollution.asp)

The next pre-harvest concern involves field location and soil usage. In the module, an introduction of why location and soil are concerns and what aspects need to be taken into consideration when choosing a field location are presented.

Soil can affect produce in many ways. Plants can absorb contaminated material through the soil and also from water becoming contaminated as it interacts with soil. To make sure the soil is acceptable, it is extremely important to determine the levels and concentrations of the specific contaminants. Testing the soil and making sure contaminant presence is low will decrease the chances of having any microbial or chemical hazards from occurring later in processing.

The soil may have been contaminated by previous or current land use. Some of the sources that could lead to soil contamination are: previous use that accidentally allowed heavy chemicals to enter the soil, water runoff, or any other structures that may leach the chemicals into the soil. It is also important to remember that some chemicals exist naturally in soil. Have the soil tested to make sure the soil doesn't contain abnormally high amounts of hazardous chemicals.

To avoid hazards from soil, avoid ingestion and skin contact as much as possible. Ingestion can result in either chemical or microbial illness, and potential irritants can get on body surfaces (resulting in rashes).

#### Soil contamination resources:

- [http://www.euro.who.int/\\_data/assets/pdf\\_file/0009/119187/E64737.pdf](http://www.euro.who.int/_data/assets/pdf_file/0009/119187/E64737.pdf)
- [http://cwmi.css.cornell.edu/Soil\\_Contaminants.pdf](http://cwmi.css.cornell.edu/Soil_Contaminants.pdf)
- [http://louisville.edu/cepm/publications/practice-guides-1/PG25%20-%20Urban%20Agriculture%20-%20Soil%20Contamination.pdf/at\\_download/file](http://louisville.edu/cepm/publications/practice-guides-1/PG25%20-%20Urban%20Agriculture%20-%20Soil%20Contamination.pdf/at_download/file)

The purpose of this section is to inform about tests that need to be run prior to field usage. This slide also emphasizes different variables on how contaminated soil can lead to harmful components on the produce.

Please refer to the previous slide for specific details or the link in the references section for further information on soil contamination.

The next microbial topic is over the use of manure and biosolids. It is very important to make sure compost has been thoroughly processed. Improperly composting or manure processing can lead to increased microbial growth, resulting in detrimental use on produce. The compost must come from a reliable source. If compost or manure is obtained from an unreliable source, it may not have been properly processed, making it unsafe and should not be used in the field.

It is important to remember to record how long the material has been composting at the optimal temperature between 135-160 degrees Fahrenheit. These temperatures should be reached to get microbes to actively decompose the various wastes. Compost should be turned to ensure temperatures are consistent throughout.

After this section, employees should understand what compost is, what information needs to be recorded from the composting, and where the compost should be stored prior to being applied on the field.

#### Biosolid and compost usage resources:

- <http://www.ext.colostate.edu/mg/gardennotes/246.html>
- [http://whatcom.wsu.edu/ag/compost/fundamentals/needs\\_temperature.htm](http://whatcom.wsu.edu/ag/compost/fundamentals/needs_temperature.htm)
- <http://extension.psu.edu/food/safety/farm/resources/manure/composting-criteria-for-animal-manure/view>
- <http://www.hvmsd.org/docs/FERTILIZERS.pdf>

Domestic and wild animals need to be kept out of the field at all times. Animals transfer disease in many different ways. One of the ways illness can be transferred from animal to fresh produce is when animals defecate on produce items. The fecal material from the animals contains harmful microorganisms which can cross-contaminate the soil or produce. One microorganism that is directly related to fecal contamination is *Escherichia coli* 0157:H7. Fecal matter from animals is the source for this bacterium. This bacterium has a very low infectious dose, meaning it can cause serious illness with very few cells. This bacterium will result in symptoms of bloody diarrhea and abdominal cramps. For those that are immune-compromised, hemolytic uremic syndrome can occur, which leads to the death of red blood cells, and will eventually cause kidney failure.

Another way animals contaminate the produce is from dirty hair or unclean paws. Much like humans, animals without proper hygiene are much more likely to cause contamination of the produce. Because animals don't bathe on a regular basis, they are more likely to have harmful microorganisms on their bodies.

By eliminating animal presence, there will be a lower risk of soil or produce contamination in the field. This can be combated by protecting the field with physical barriers (fences), or other sprays and repellents that will prevent animals from entering the field.

### Animal hazard resources:

- <http://gardening.wsu.edu/stewardship/compost/petpoop.htm>
- [http://www.epa.gov/safewater/sourcewater/pubs/fs\\_swpp\\_petwaste.pdf](http://www.epa.gov/safewater/sourcewater/pubs/fs_swpp_petwaste.pdf)
- <http://mtwatercourse.org/media/downloads/Pet%20Waste.pdf>

This portion of the module is included to show examples of contamination from animals. Workers should grasp that if they see any similar breach in the perimeter, it is very important to inform their boss or owner of the field. The image on the left shows animals have the ability to dig under fences, while the image on the right shows potential damage that could be done if animals gained access to the field. Once inside, it is difficult to tell if animals have defecated or contaminated the produce. Therefore, the best solution is to conduct frequent inspections of the perimeter of the field.

Chemical hazards are another form of hazard that can occur during pre-harvest. This section introduces different types of chemicals used in fields.

A few of the manmade chemicals are pesticides, herbicides, and sanitizers.

Pesticides are used to keep animals away from the field so they cannot contaminate the produce through direct contact or fecal contamination. Herbicides are used to prevent weeds and other unwanted plants from growing and interfering with produce production. Various sanitizers are used on the field to help reduce risk microbial contamination from occurring, such as sanitizer used to clean harvesting equipment.

There are certain natural chemicals that plants produce that can lead to chemical contamination. A specific example is patulin in apples. When apples begin to rot, they produce a natural toxin. This toxin has the ability to affect the immune system, nervous system, gastrointestinal tract, and cause DNA damage in humans, and the apple should not be consumed at this stage.

After viewing, students should understand that there are both natural and manmade chemicals that can potentially contaminate the produce, making it unsafe.

### Chemical hazard resources:

- <http://www.who.int/ceh/risks/cehchemicals2/en/index1.html>
- [http://www.crec.ifas.ufl.edu/extension/trade\\_journals/2010/2010%20April%20food%20safety%20hazards.pdf](http://www.crec.ifas.ufl.edu/extension/trade_journals/2010/2010%20April%20food%20safety%20hazards.pdf)
- <http://www.food.gov.uk/multimedia/faq/patulin/#.UfAzTJU1ZII>
- <http://www.gov.mb.ca/agriculture/foodsafety/processor/cfs02s145.html>

Now the modules show how to prevent chemical contamination from occurring during pre-harvest production.

The first way to prevent chemical contamination from occurring is to have trained employees. Training employees about potential chemical hazards in the field will familiarize them with what they should and shouldn't do with available chemicals. Training should be done frequently to make sure employees do not forget these

important guidelines. During this training, employees should also learn about appropriate chemical application. This should include who is to apply the pesticides and herbicides, and use the sanitizers.

All chemicals should be stored in a location away from the field. Chemical storage should also be secure and locked when not in use. By locking up chemicals, unauthorized application or use cannot occur.

To reduce risk of naturally occurring chemical hazards, rotten produce should be disposed of appropriately. Physical inspection of the produce before placing items in the harvest bins will reduce chances of having natural chemicals spread to good quality produce items.

Physical hazards are the final type of hazards. These types of hazard have the ability to become embedded in the produce, potentially harming the consumer when ingesting, or harm the worker during harvest. Different forms of physical hazards that may be encountered are metal, broken glass, sharp wood from bushes or trees, stones from the field originally, or hard plastic waste products left in the field. The purpose of this slide is to inform about the variety of physical hazards that may be encountered in the field.

Once introduced to physical hazards, workers need to know how to prevent or remove these hazards if found in the field. Performing routine inspections of the field will result in removal of physical hazards promptly, thus reducing risk for others. Physical hazards should be disposed of in a designated waste receptacle. This includes produce items embedded with physical hazards. Properly disposing of these hazards in a careful manner will reduce chances of physical harm to consumers and reduce chances of harm for workers. The purpose of this portion of the training module is to inform the audience on what to do when physical hazards are seen.

The final section of the pre-harvest training module reiterates the main concepts mentioned throughout the section. All of produce food safety starts with Good Agricultural Practices. Safety components that go into a successful food safety plan are Good Manufacturing Practices, Sanitation Standard Operating Procedures, and Standard Operating Procedures. For specific information on each of the hazards, please view the specific slide from earlier in the module, or view designated links in the references section.

After all key components of the pre-harvest section are summarized, the second quiz of this training module can be taken. Please pause the module now and distribute quizzes accordingly.

This quiz will focus on components of a successful food safety plan, and the microbial, chemical and physical hazards during pre-harvest production of produce. The quiz will also address prevention steps to eliminate or reduce the risk of the hazard. Below is the answer key to the second quiz:

**Quiz questions for university module: QUIZ 2**

- 1) The final food safety plan that brings together all of the other food safety aspects is called the \_\_\_\_\_ plan.
- A) GMPs
  - B) SOPs
  - C) HACCP
  - D) SSOPs

Answer: The final food safety plan is the HACCP plan. It brings together Good Agricultural Practices, Good Manufacturing Practices, Standard Operating Procedures and Sanitation Standard Operating Procedures. The complete HACCP plan helps minimize the risk of produce contamination from occurring at all stages of preharvest and postharvest production.

- 2) Which of the following is NOT a biological hazard in pre-harvest produce food safety?
- A) Improper soil and manure usage
  - B) Pesticides applied to the field
  - C) Water contamination
  - D) Wild and domestic animals

Answer: Pesticides would not be considered a biological hazard. They would be considered a chemical hazard. Improper soil and manure could contain high levels of harmful microorganisms. Pathogens can also be found in surface water or well water that hasn't been tested. Wild animals can act as a vector for pathogens through cross-contamination.

- 3) When do we have to begin thinking about pre-harvest safety?
- A) When the seed is planted
  - B) When the seed is watered for the first time
  - C) When a sprout can be seen above ground
  - D) When the field site is selected

Answer: We have to consider pre-harvest food safety even before planting our fresh produce. Initially, field site selection should be examined to make sure the location is a safe place to grow produce. The field site should be free from heavy metals (lead), and should not contain high levels of pathogenic microorganisms.

4) How many days prior to harvest must raw manure be applied according to the National Organic Standards?

- A) At least 90 days
- B) At least 120 days
- C) At least 180 days
- D) At least 365 days

Answer: Raw manure must be applied at least 120 days prior to harvesting produce.

5) What is one type of toxin found naturally in apples that can cause illness if ingested?

- A) Pesticide
- B) Herbicide
- C) Botulism toxin
- D) Mycotoxin

Answer: Mycotoxins are natural toxins that can be found in apples. Both pesticides and herbicides are chemicals that are manmade and have been engineered to reduce pests from fresh produce. Mycotoxins are a chemical hazard and can result in illness if ingested.

6) What should be done to reduce chances of physical hazards from occurring?

- A) When you see physical hazards, step over them and continue working
- B) Monitor the field frequently, and safely remove physical hazards when they appear
- C) Find a way to mark where the physical hazards are, and pick them up at the end of your shift
- D) Physical hazards should be left for other workers to pick up

Answer: To reduce physical hazard presence in the field, it is important to have them safely removed immediately. They should not be left in the field, because they can cause harm to another individual later or yourself if you travel back and forget about it. It is every workers responsibility to take action and remove the physical hazards once they are observed.

7) What is the best way to start implementing an effective food safety plan?

- A) Start with a HACCP plan
- B) Start with SOPs
- C) Start with GAPs
- D) All of the above are good ways to help implement an effective food safety plan



Answer: All of the above are beneficial when implementing a food safety plan. GAPs are the foundation of a food safety plan. Once implementing GAPs, SOPs and SSOPs should be developed to combat additional hazards that may occur during postharvest processing. The entire HACCP plan can be developed once the GAPs, GMPs, SOPs and SSOPs are created for the food safety plan.

8) What harmful substances could be found in water?

- A) Fecal coliforms
- B) Nitrates
- C) Microorganisms from humans
- D) All of the above

Answer: Water is of big concern when considering produce food safety. Fecal coliforms, nitrates, and microorganisms from humans can all be found in water. Water samples should be taken to confirm that water used is potable, and safe for human health.

9) What is important to know before using compost?

- A) The nutrient content
- B) The source
- C) The field's needs
- D) All of the above

Answer: The nutrient content, the source, and the field's needs are all important characteristics when considering compost.

10) Which of the following is a GAP topic?

- A) Water
- B) Soil
- C) Worker Health & Hygiene
- D) All of the above

Answer: Water, soil, and worker health and hygiene are all important GAP topics when considering produce food safety. Water and soil come in direct contact with fresh produce in pre-harvest and have to be monitored throughout its growth. Worker health and hygiene is also an important aspect. Worker poor personal hygiene could result in cross-contamination of the fresh produce.

The next step of produce production is post-harvest processing. In this section of the module, the term, “post-harvest,” is defined with specific objectives of hazard identification from microbial, chemical and physical risks during this phase of production and how to reduce or remove these risks addressed.

After produce has been picked from the field, it is important for workers to know how important the work they do is. The Farm-to-fork approach is a way of explaining safety in produce production. It means that produce workers must safely handle produce from when it is grown in the field, to when it reaches the “fork” of the consumer that purchased the item. This slide shows how to effectively clean, sort, pack, store, and transport the produce. It is important to emphasize that the steps should be done in this specific order to properly clean the produce. Cleaning most produce after harvesting involves an initial rinse step for any potential hazards that may be on the surface of the produce. After rinsing, the produce should be sorted. As part of the sorting step, visual inspection by employees may help discover any undesirable fruits or vegetables, or may even help show some that have physical hazards present in or on the produce. After washing, produce should be stored at the correct temperature for that type of item in order to maintain quality and shelf life. Correct storage temperatures also help reduce the chance of having increased microbial growth on the produce. Records that appropriate measures have been taken throughout the process provide documentation that there are minimal risks when produce leaves the facility. Each of these steps is important, and there are many different actions that need to occur at each step to make sure produce is safe.

This section introduces each subsection of post-harvest processing to prepare learners for the upcoming portion of the module. Each of these five steps is where hazards can exist. Further detail to what is presented in the module is included in this teaching manual.

The first area of post-harvest handling where hazards can arise is at harvest. Good agricultural practices must be followed during harvest. The module explains why harvest bins must be properly maintained and why produce needs to be rinsed prior to storage. These bins should stay off of the ground to reduce chances of cross-contamination from potential harmful chemical or microbial agents from the soil. To reduce microbial buildup, the bins should be washed daily. This will also help remove any potential physical hazards that have gathered in the bottom of the bins during harvesting.

Separate bins for newly harvested post-harvest items helps reduce chances of cross-contamination from occurring. Once the produce is brought into processing facility, it is washed and further cleaned. If the clean item were placed back in the same harvesting bin, microorganisms from what the initial harvest bin was carrying could contaminate the produce. Pre-harvest and post-harvest bins should also be kept in separate locations (which employees know about) to reduce confusion on which bins are used for each part of processing.

Due to all of the potential hazards that may be present on the produce from the pre-harvest section, it is important that most produce is rinsed with potable water prior to entering the facility. This will remove any additional dirt, debris, and potential harmful microorganisms from the surface of the produce. However, not all produce is washed or rinsed.

Once produce has been harvested, it is taken to a building, facility, or area for processing, which involves cleaning, sorting, and packing of product. Workers must understand that without daily cleaning of the processing facility, there is an increased risk of microbial hazards. Workers will learn how to properly clean the facility yet not to over sanitize. Applying too much of a chemical sanitizing agent, such as bleach, could lead to chemical contamination and add a chemical hazard into the process. All chemicals should only be used according to label directions.

To maintain proper processing controls, the facility itself must be frequently evaluated to ensure it is free from rodents, insects, and debris. Animals can transfer diseases or defecate that will contaminate the processing facility; therefore the best processing facility should be off limits to pests. An enclosed workspace is best for the processing segment of produce production.

Floors, ceilings, and light fixtures should be cleaned regularly to avoid build up of dust and dirt that could contaminate the product or packing containers.

Restrooms and hand washing stations in the facility should also be cleaned regularly and checked that adequate supplies are available. Cleaning the wash stations will reduce chance of potential microbial contamination. Lastly, work lockers and storage areas should be cleaned and kept orderly. These should be located away from the processing area.

By following these procedures, physical, chemical, and microbial hazards will be reduced or eliminated.

#### **Facility sanitation resources:**

- <http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-959/FAPC-121web.pdf>
- [http://www.utexas.edu/safety/ehs/food/sanitation\\_requirements.html](http://www.utexas.edu/safety/ehs/food/sanitation_requirements.html)
- <http://edis.ifas.ufl.edu/fs076>

It is also important for workers to understand how to properly manage and dispose of wastes, such as rotten produce. It can either be completely disposed of, or composted.

Wastewater is another potential waste that can negatively influence the produce. This water was used to clean the initial produce; therefore this water cannot come in contact with the produce once it has been used (otherwise it may contaminate the produce with the hazards it initially removed).

Waste locations need to be kept away from the growing site and processing area. If wastes are allowed to accumulate near the garden, cross-contamination can easily occur. Physical hazards can blow into the field; chemicals and microorganisms could get into the field soil through runoff.

Produce must be properly stored after it has been cleaned. Students will learn that if produce is not stored at the appropriate temperature for the type of item, both the quality and safety of the product will be compromised. “First in, first out,” is a practice that is followed to reduce product waste. With “First in, first out,” the produce placed in storage first should be sent out before produce that is just entering into storage.

The storage location should be checked frequently to make sure appropriate cleaning practices are followed. As part of monitoring, the thermometers in the storage area should be checked to make sure the produce is kept at the desired temperature until it is sent out.

#### Temperature and shelf-life resources:

- [http://www.fns.usda.gov/fdd/programs/dod/DoD\\_Training\\_Prg-StorageFFV-071405.pdf](http://www.fns.usda.gov/fdd/programs/dod/DoD_Training_Prg-StorageFFV-071405.pdf)
- <http://ucce.ucdavis.edu/files/datastore/234-1920.pdf>
- [http://msue.anr.msu.edu/news/proper\\_produce\\_storage](http://msue.anr.msu.edu/news/proper_produce_storage)
- [http://www.kent.k12.wa.us/cms/lib/WA01001454/Centricity/domain/9/f2s%20images/Fresh%20Produce%20Storage%20Tips\\_WSDA.pdf](http://www.kent.k12.wa.us/cms/lib/WA01001454/Centricity/domain/9/f2s%20images/Fresh%20Produce%20Storage%20Tips_WSDA.pdf)
- <http://www.gardening.cornell.edu/factsheets/vegetables/storage.pdf>

In addition to storage temperature, produce must be stored in storage areas away from any potential microbial, chemical, or physical hazards.

For best storage results, harvest the produce items at peak maturity. Do not store produce that has insect damage or extreme cuts or bruises. These produce items are more likely to quickly decline and potentially have microbial contamination.

It is very important to make sure that there is no standing water where the vegetables are stored. Standing water will increase the incidence of rotting and significantly decrease shelf life and quality of the product.

Keep products away from pests so fecal or cross-contamination cannot occur. It is important to never store produce where chemicals are stored. If chemicals were to leak from their bottle and make contact with the produce, they would be contaminated and unsafe for consumption.

Produce storage resources:

Transportation of product could lead to cross-contamination to produce if done incorrectly. When transporting harvested produce, clean vehicles should be used and the product kept protected. Two of the biggest concerns when transporting produce from field to processing facility are debris that could land on the produce or in the harvesting bins and fecal contamination from birds. There is less risk if the produce is not exposed to the open environment before entering and leaving the processing facility, the better.

Record keeping is one of the most important management aspects of food production. The module stresses that records need to be maintained for traceability reasons, should an outbreak occur. Specific records must also be maintained daily and filed if an inspection were to occur. But records also document that appropriate practices are being performed and the produce is being properly handled from farm to fork. Records of where the produce came from, who harvested it, the amount distributed, and where it is being sent should be kept. By knowing where the produce came from, it will be possible to find out where an outbreak originated. Knowing how much was distributed will allow you to see how much of the product could be compromised. By maintaining records of where the produce is sent, it can be recalled and evaluated before more threat to the consumer arises.

Records of water and soil testing must document that there are no harmful microbes or chemical agents in the water and soil. By maintaining these records, you will be able to prove that you are using clean resources that are safe for produce processing. If no records were kept, there is no proof that hazardous soil and water are not being used.

Records of produce storage areas helps managers monitor and maintain the appropriate storage environment. If produce is kept outside of appropriate temperature conditions, damage and microbial growth can occur, resulting in spoiled produce or harmful microorganism growth.

It is also important to keep records of cleaning and sanitizing practices to document the facility itself presents no microbial risks.

Lastly, records documenting employees have received safety training prove that the organization has communicated proper practices to staff.

The take home message is that if information is not recorded, it never happened.

Records help verify that GAPs, GMPs, SSOP, and SOP are being followed.

Record keeping can be confusing to those not familiar with the process. This portion is included to visually show different types of forms or documents that may be used in record keeping. Records can be kept on paper or electronically with the files stored on a flash drive or external hard drive as a safety measure.

Please remember to pause the module at this time. Allow workers time to critically think or interact with each other to determine which record keeping practices are the best and those which are poorly done. Once the activity has been completed, please continue the training module.

In this section of the online training module, post-harvest chemical hazards that may arise during post-harvest processing and what risks they pose to the produce are presented.

In the facility, many cleaners, sanitizers, detergents, and lubricants are used to make sure the equipment is clean and properly functioning. It is very important to make sure that all chemicals used in the facility are food grade. Much like in pre-harvest processing, do not over apply chemicals. Whoever is designated to work with the chemicals stored in the processing facility should follow appropriate procedures for

each chemical to protect their personal safety as well as avoid contamination of the product.

When using over the counter pest control chemicals, these should be applied during off-processing hours to avoid direct contact with the produce. All surfaces in contact with the chemicals should be cleaned and sanitized prior to contact with processing and storage areas to avoid any potential cross-contamination.

It is important to never use chemicals for anything *other* than their specific purpose. Incorrect chemical usage can lead to chemical illness. Make sure to properly train employees on all chemicals that will be used and have clear procedures defined.

Physical hazards might occur from any metal that may be present in the facility if tools are broken or processing equipment falls/breaks off during processing. If glass bottles are used, broken glass may get embedded in the produce or potentially break the skin of a worker. Wood could be present in the facility when the produce is brought in with the harvesting bins. Various types of plastic may be used in processing facilities. Workers must also understand that machinery may break or pieces may come loose when processing. All of these physical hazards need to be emphasized to those working in the processing area so they know what to expect and how to successfully prevent these hazards from occurring.

Prevention is the best practice. Visual inspection will allow the worker to see if any metal fragments or other sharp harmful objects are embedded in the produce item. To even further reduce risk of physical contamination, workers should never wear necklaces, rings, earrings, or other forms of jewelry when in direct contact with the produce. These jewelry items could fall off into the batch of produce being processed and become a physical hazard.

If possible, metal detection units are a wonderful source to alert workers of some physical contamination. It is important to remember that if you have a metal detection system set up, visual examination should also be performed because not all physical hazards are metal.

It is also very helpful to use equipment that will filter out some of the initial dirt and debris from the produce that was just harvested. Filtering out these impurities will remove some of the other physical hazards that may initially be present (small stones/rocks, wood pieces, metal fragments from the soil).

A brief reminder of where hazards can occur once produce is transported into the processing facility is presented (Additional information on each topic can be found in the references section of this training).

At this point, participants will be tested over the potential microbial, chemical, and physical hazards that can occur during post-harvest processing. Be sure to pause the training module until students have finished the quiz.

This quiz will focus on where each type of hazard can occur and what preventative steps the worker can take to reduce risk or prevent contamination from occurring. It will also test over record keeping practices to make sure that they have an

understanding of why records are kept, and how they should appropriately store them. Once completed with the quiz, continue the training module for the final subsection of produce food safety. Below are the answers to the quiz:

### Quiz questions for university module: QUIZ 3

1) What do we call the “Start-to-finish” approach in produce food safety?

A) “Field-to-finger” approach

B) “Farm-to-fork” approach

C) “Seed-to-spoon” approach

D) “Garden-to-gut” approach

Answer: The “start-to-finish” approach in produce food safety is called the “farm-to-fork” approach. We use this phrase to help explain where risks can occur throughout the production of fresh produce. The beginning of produce processing begins in the field, or “farm.” GMPs are used in this section for risk management. When we harvest, we continue with production of produce until we package it for consumers. “Fork” represents that all additional chemical, physical, and biological risks must be considered until the produce reaches the consumer’s table.

2) When does post-harvest processing start?

A) When the produce is packaged

B) When the produce is sent to the grocery store or farmers’ market

C) When the produce is removed from the plant/field

D) When the body starts to digest them

Answer: Post-harvest starts immediately following removal from the plant or field. After harvesting, the produce will go through a series of steps prior to reaching the consumer. There are many food safety risks we have to consider between harvesting and transportation of fresh produce to consumers.

3) Which of the following is NOT a post-harvest produce food safety hazard?

A) Usage of biosolids and compost

B) Proper storage of produce

C) Transportation/distribution of produce

D) All of the above can be post-harvest produce hazards

Answer: Usage of biosolids and compost is not a post-harvest produce food safety hazard. Biosolids are applied to produce and used to help increase nutrients during produce production, making it a pre-harvest produce food safety hazard. After harvest, produce must be stored at the appropriate temperature and humidity and transported at the desired conditions.

- 4) What is the difference between “clean” and “sanitary”?
- A) Clean is a reduction of harmful microorganisms to levels that are no longer harmful; Sanitary is free of visible soil or other materials
  - B) Clean is free of visible soil or other materials; Sanitary is a reduction of harmful microorganisms to levels that are no longer harmful
  - C) Clean and Sanitary are the same thing
  - D) None of the above describe the difference

Answer: By definition, clean is free of visible soil, where sanitary is a reduction of harmful microorganisms to levels that are no longer harmful.

- 5) Why is it important to keep harvesting bins off of the ground?
- A) The bins can pick up harmful microorganisms from the soil
  - B) The bins may pick up fecal contamination from wildlife or birds
  - C) The bins could get mixed up; Good and bad produce could get mixed together
  - D) All of the above are reasons to keep harvesting bins off of the ground

Answer: Harvesting bins must always be kept off of the ground when harvesting fresh produce. Bins may become cross-contaminated from harmful microbes in the soil. The bins may also come in direct contact with fecal material, which will also cross-contaminate the bins. By keeping the harvesting bins off of the ground, there is less chance for microbial hazards through cross-contamination.

- 6) How should preparation surfaces be to reduce microbial growth?
- A) The surfaces should be porous and absorbent
  - B) The surfaces should be smooth and absorbent
  - C) The surfaces should be smooth and non-absorbent
  - D) The surfaces should be porous and non-absorbent

Answer: It is important to use surfaces that are smooth and non-absorbent for preparation surfaces. Harmful microbes could soak into absorbent material, causing further contamination and biological hazards in future production of produce. If surfaces are porous, microbes can remain present in the grooves of the surface when not properly cleaned or sanitized.



- 7) What are specific things to look for when keeping the processing area sanitary?
- A) Check the walls and ceilings for cracks
  - B) Check equipment for loose or missing pieces
  - C) Make sure windows and doors are closed that lead into the processing facility
  - D) All of the above can affect the sanitary practices in post-harvest processing

Answer: It is important to look at many different factors when evaluating the sanitation in the processing area. When inspecting the processing area, ceilings and walls must be checked for cracks. They must be repaired to prevent entry from external pests. Equipment must also be checked regularly for loose or missing pieces. Pieces could have fallen into fresh produce, increasing physical hazard risk. Lastly, the facility should be secure. Closing doors and windows will prevent any additional pests and non-approved personnel from coming in direct contact with recently harvested produce.

- 8) How should wastewater be disposed?
- A) Apply it to the field. Any extra water helps.
  - B) Take it to the nearest building and dump it down the sink
  - C) Dump it near the field so it can still be used but is not directly on the produce
  - D) Move it away from the field and the washing and packing areas to dump it

Answer: Wastewater should be disposed of away from the field and away from washing and packing areas. We cannot be certain if harmful chemicals, physical objects, or bacteria are present in this water. To prevent recontamination to our fresh produce, we have to make sure the produce does not come back in contact with wastewater.

- 9) When storing produce, what saying is used to maximize product usage and minimize wastes?
- A) "Good first, bad later"
  - B) "First in, last out"
  - C) "First in, first out"
  - D) "Last in, last out"

Answer: We use the saying, "First in, first out," to maximize produce during postharvest production. When removing produce from storage for distribution, it is important to remove earlier harvested produce than more recently harvested produce. Since produce has a short shelf-life, older produce must be sent first to maximize yields and minimize wasted produce.

- 10) How should chemicals be applied in post-harvest produce food safety?
- A) Apply chemicals to the surfaces; the more concentrated, the better
  - B) Just use enough chemical to cover the surface. Anything more is wasteful
  - C) Look at the back of the chemical and mix them according to the instructions. Chemicals should be strong enough to be effective, but not too strong to harm
  - D) Only use chemicals in pre-harvest produce food safety

Answer: Chemicals should always be applied according to the label. A chemical risk will result if too much chemical is used. However, if not enough chemical is used it will be ineffective. There will be a reduced chemical risk and an effective chemical solution if applied according to the label.

A large portion of produce is contaminated because workers fail to follow proper hygienic practices. This section covers that material.

This section focuses on a few of the more common ways direct contamination and cross-contamination can occur with produce, and why employee training is essential when handling produce items. Additional information will be included in this teacher's manual when each of these specific concepts are introduced individually.

Contamination and cross-contamination can occur because of poor health and hygiene practices of those working around the food.

Coming to work ill with symptoms of diarrhea, vomiting, fever, coughing, sneezing, or a sore throat is one way produce can become contaminated. Employees may sneeze directly on product or product contact surface or contaminate product through their hands, particularly if hands are not washed properly. Many microorganisms are found in fecal matter; diarrhea can transfer potentially harmful microbes (like *E. coli* 0157:H7 in fecal material) to the product. Vomiting and sore throat can also transfer harmful microorganisms if the produce becomes exposed to them. It is important to emphasize to workers that they cannot come to work or handle the produce if they have any of these symptoms.

This portion of the online module gives some real world examples to illustrate points made in previous module material. Participants should understand that microorganisms can be anywhere on hands, and it is important to be thorough when washing hands to prevent illness to the consumer.

The images show harmful microorganisms that can be present on your hands, in addition to the locations where they could be.

The image on the right visually shows how important proper hygiene is, especially after restroom usage. Each spot on the plate represents one microorganism, showing that there are lots of microorganisms on our hands.

After introducing the importance of hand washing, students will learn the six-steps of hand washing. Each step of proper hand washing is further explained in the script, to go along with the visuals in the slide. For proper hand washing, make sure employees have access to hand sanitizer or soap, potable water, and clean disposable towels.

In the first step of hand washing, employees should rinse their hands with warm running water (or at least potable if warm is not available). The initial rinse step will remove the initial presence of microorganisms from their hands. After rinsing, employees must apply soap. The soap will supply additional agents that will help loosen and remove any microorganisms that were still present on their hands after the initial rinse. Once applied, employees must make sure to lather the soap all over their hands and wrists for the next 10-15 seconds (or as long as the “Happy Birthday” song). This time frame will make sure that the soap has effectively been applied to all areas of the hands and the lathering provides abrasion to help lift resistant soils from hands. Employees must remember to clean under their fingernails and in between their fingers because these regions are much more challenging to reach, which allows for more microbial growth or initial presence. Next, rinse all of the areas where soap was initially applied (wrists, palms, back of hand, under fingernails). The last step is drying hands with a single-use towel or paper towels. Towels should not be used multiple times, otherwise potential microbial buildup could occur, resulting in cross-contamination from the unclean towel to the employee’s hands. The same principle applies to using clothing as a drying towel.

An organizations’ SOP for hand washing should be clearly communicated with reinforcement signage posted at appropriate locations. Some examples of these are listed below and address the diversity in workers’ cultures and literacy levels. Sanitizers are not an effective substitute for soap and water and not accepted as part of the GAP audit conducted by USDA as a substitute for hand washing stations. In addition, while sanitizers contain at least 60% alcohol can be effectively in reducing levels of some microbes on the hands, it is important to remember that alcohol-based sanitizers do not remove norovirus, a virus commonly found on hands of people and frequently associated with produce related illnesses.

#### Personal Hygiene resources:

- <http://www.health.gov.au/internet/publications/publishing.nsf/Content/ohp-enhealth-manual-atsi-cnt-l~ohp-enhealth-manual-atsi-cnt-l-ch3~ohp-enhealth-manual-atsi-cnt-l-ch3.2>
- [http://www.health.vic.gov.au/foodsafety/downloads/hygiene\\_personal.pdf](http://www.health.vic.gov.au/foodsafety/downloads/hygiene_personal.pdf)
- <http://www.bromley.gov.uk/leaflet/260991/13/756/d>
- [http://www.northdevon.gov.uk/index/lgcl\\_environment/nonlgcl\\_environmental\\_health/nonlgcl\\_food\\_hygiene\\_and\\_safety/nonlgcl\\_food\\_safety\\_tips/nonlgcl\\_food\\_safety\\_tips\\_personal\\_hygiene.htm](http://www.northdevon.gov.uk/index/lgcl_environment/nonlgcl_environmental_health/nonlgcl_food_hygiene_and_safety/nonlgcl_food_safety_tips/nonlgcl_food_safety_tips_personal_hygiene.htm)
- <http://www.cdc.gov/features/handwashing/>

- <http://www.bidmc.org/YourHealth/Holistic-Health/How-to-Wash-Your-Hands-Properly.aspx>
- <http://homefoodsafety.org/safety-tips/wash>
- <http://www.cleanhandscampaign.org/wash.htm>
- <http://www.fda.gov/downloads/Food/FoodSafety/RetailFoodProtection/ManagingFoodSafetyHACCPPrinciples/Regulators/UCM078159.pdf>
- <http://homefoodsafety.org/safety-tips/wash>
- <http://nfsmi.org/documentlibraryfiles/PDF/20091123115356.pdf>

The next personal hygiene concept explained is proper restroom usage. The purpose of this section of the online module is to reinforce that it is necessary to use proper facilities to avoid contaminating the product. From the previous section, employees should understand all of the necessary items that are needed for proper restroom usage. It is extremely important to reinforce that defecating or urinating in the field is prohibited.

When working in direct contact with produce, it is very important to wear adequate clothing. Not only should clothes be washed prior to working in the field, but they should also not be tattered or ripped. Loose items on clothing may fall off and end up as a physical hazard later in produce processing. The physical pieces could break when entering the processing line and add additional physical hazards later. This can contribute to both physical and microbial hazards. By not wearing these potentially dangerous items in the field, there will be a lowered chance for physical hazards to occur. Inform the workers and students on the dress requirements before they enter the field.

The purpose of this portion of the module is to summarize how to reduce different forms of improper hygiene.

Initially, employees have to meet specific qualifications and training requirements. They should have this training completed before they ever handle any of the produce, whether it is pre-harvest or post-harvest. After employees have completed this training, it must be properly documented. By documenting the hygienic training, there is proof that the employees have received this information and therefore should be knowledgeable and qualified to handle produce at all stages of production. The biggest thing employees need to remember is to always wash hands before and after handling produce to avoid direct and cross contamination.

There are other ways cross-contamination can occur on produce. Here, fomites will be described, and which fomites they may encounter when processing produce. Washing surfaces with soap or detergent and water initially can help reduce the overall microbial load on the fomite. Wear protective gear, soak the area with hot detergent, wash the area where contamination is of concern, rinse the area to remove all of the detergent residue that was initially applied, and allow the area to fully dry.

The proper steps are slightly different when disinfecting an area with application of a chemical sanitizing agent. First, make sure to read and follow the instructions on the product label.

By following these procedures for cleaning and sanitizing, the chances of fomite cross-contamination will be significantly reduced.

#### **Fomite resources:**

[http://www.cfsph.iastate.edu/BRMForProducers/English/RouteSpecificInformation/fomite\\_management.pdf](http://www.cfsph.iastate.edu/BRMForProducers/English/RouteSpecificInformation/fomite_management.pdf)

The final section of this training module tells about some of the major food regulations. Workers are introduced to which food regulation laws are related to produce, why regulations are set in place, and which regulations are mandatory and must be followed.

To have workers get a better understanding of the different types of regulations, an introduction to each type of regulation is presented next. For each level, a specific regulation/example is stated for the student.

Federal regulations are mandatory throughout the nation. All food processors and/or preparers must follow these laws. For a list of the federal regulations, go to: <http://www.gpo.gov/fdsys/browse/collectionCfr.action?selectedYearFrom=2013&go=Go>. The two regulations that will be of use are title 7 (Agriculture) and title 21 (Food and Drugs).

State regulations are specific to the state, but must be followed by everyone in that state. State regulations may vary state to state, because produce items differ between state lines.

Local regulations are laws that are specific to a localized area, such as a city or county. These regulations would be applicable to a farmers' market setting or local farmer selling produce.

It is important participants understand that regulatory oversight is there to protect the public's health and that part of their job in the workplace is to follow all regulations at the organizational, local, state, and federal levels that apply.

#### **Regulation resources:**

- <http://www.fas.org/sgp/crs/misc/RS22600.pdf>
- <http://www.fao.org/food/food-safety-quality/capacity-development/food-regulations/en/>
- <http://www.gpo.gov/fdsys/browse/collectionCfr.action?selectedYearFrom=2013&go=Go>

Because this training module is specifically intended for produce food safety, this section discusses the Food Safety Modernization Act (FSMA) and why it is important when handling produce. The goal of this regulation, revised in early 2013, is to

prevent contamination, rather than looking at ways to respond to contamination when it occurs. The Food Safety Modernization Act now allows the Food and Drug Administration to order recalls of contaminated food (this is an added power for the FDA).

#### **Food Safety Modernization Act resources:**

- <http://www.fda.gov/Food/GuidanceRegulation/FSMA/default.htm>
- <http://www.fda.gov/Food/GuidanceRegulation/FSMA/ucm239907.htm>
- <http://www.foodsafety.gov/news/fsma.html>
- <http://www.fda.gov/downloads/Food/GuidanceRegulation/FSMA/UCM359258.pdf>

The purpose of this section is to inform workers on where the food products may go, and to reinforce that there are a wide variety of food regulations, depending on the venue, whether it is a food service or farmers' market.

In this section, workers will learn that immune systems vary among people, and food items must be safe for those who have lowered or weakened immune systems. The individuals that are at highest risk of illness from ingestion of contaminated food products are pregnant women, young children, older adults, and individuals with lowered immune systems.

Pregnant women have lowered immune systems because they have to help support the growing unborn baby.

Younger children have lowered immune systems because their bodies have not fully developed yet. These children will eventually have stronger immune systems (unless they are born immune-compromised).

The elderly are another group of individuals that the workers have to consider.

Unlike the growing immune systems of the young, the elderly have a declining immune system. As we get older, our immune system is less effective at fighting off potential harmful agents that enter our body.

The last group of individuals with lowered immune system is those that are immune-compromised or have chronic illness (AIDS, cancer, diabetes). Immune-compromised individuals already have harmful agents working against their body, and their bodies will not be able to take on additional hazards that could arise from food.

Workers and students need to understand that if adequate regulations are not implemented to meet the needs for each of these groups of individuals, serious illness or death may result.

This section summarizes the material presented on proper hygienic practices, ways to reduce cross-contamination, how to properly clean and sanitize tools, and reviews importance of regulations and what types of regulations there are.

The workers will take a final quiz at this time. Please remember to pause the module as the quiz is being administered. This final quiz focuses on health and hygiene issues of workers handling produce, how to minimize direct and cross-contamination, and the different types of regulations that must be considered when handling produce. Below is the answer key to the fourth quiz:

#### Quiz questions for university module: QUIZ 4

- 1) What is the best way to wash your hands when handling produce?
  - A) A quick rinse under water is good enough
  - B) Hand sanitizer is the best way to get rid of microorganisms
  - C) Rinsing with soap and water for the adequate amount of time is the best way to wash hands and remove the greatest number of microorganisms
  - D) All of the above ways are great ways to reduce microorganisms on hands

Answer: The most effective way to wash your hands before and after handling produce is with soap and water. It is important to wet your hands, apply soap, and lather around your hands up to your wrists and in between fingers for 10-15 seconds. Once completed, remove the residual soap and dry hands with a single use disposable hand towel. A quick wash without soap will not remove all of the microbes, allowing for cross-contamination after leaving the restroom. Hand sanitizer will remove some microbes, but is still not the best method. Norovirus causes foodborne illness and can survive after hand sanitizer has been applied.

- 2) What is the cause of a significant amount of produce contamination?
  - A) Animals
  - B) Chemicals
  - C) Poor employee training
  - D) None of the above

Answer: Although all of these options can result in contamination, poor employee training has shown to impact produce contamination greatly. One large area of employee training that has shown to result in contamination is through poor personal hygiene. The Centers for Disease Control and Prevention estimate close to 50% of foodborne disease is linked to poor hand washing practices. Increased personal hygiene practices will help further reduce cross-contamination to fresh produce items.

- 3) According to the Centers for Disease Control and Prevention (CDC), about what percent of foodborne disease are linked to poor hand washing?
  - A) About 25%
  - B) About 33%
  - C) About 50%
  - D) About 75%

Answer: Almost half of foodborne disease is caused due to poor handwashing practices. It is very important to always wash hands before and after handling fresh produce. Washing hands before handling produce will reduce the risk of cross-contaminating the produce. Washing hands after handling produce will reduce the risk of cross-contaminating other objects from potential pathogens that could have been present on the produce or in the soil during harvest.

4) Hands should be washed:

- A) Prior to working with produce
- B) After working with produce

C) Both A and B

D) Hands do not have to be washed as long as disposable gloves are worn

Answer: Hands should be washed both prior to and after working with produce. When harvesting, we cannot visibly see what microorganisms could be present on the surface of the produce. To protect ourselves and others who may be consuming this produce, we want to wash our hands whenever we will be coming in direct contact with produce to reduce chances of cross-contamination from occurring.

5) When washing hands, how long should they be lathered in soap?

A) 3-5 seconds, or about enough time to introduce yourself to somebody

B) 10-15 seconds, or about the time it takes to sing "happy birthday"

C) About as long as it takes you to brush your teeth

D) About as long as you can hold your breath for

Answer: Hands should be lathered in soap between 10-15 seconds before rinsing with warm water. 3-5 seconds is not enough time for the soap to reach all areas and be effective.

6) What is a fomite?

A) A type of insect that grows in the field

B) A gardening tool used to keep the garden maintained

C) A non-living object that helps spread microorganisms from one place to another

D) A type of sanitizer that is used in post-harvest processing to keep the processing facility clean

Answer: By definition, a fomite is, "a non-living object that has the ability to serve as a vector for the spread of harmful microorganisms from one place to another."



7) What should I do if I see someone not practicing food safety?

A) Nothing, I am only responsible for my own actions.

B) Give them a gentle reminder

C) Report them to the boss

D) Report them to the FDA

Answer: If you witness individuals around you not practicing food safety, it is important to gently remind them of its importance. By reporting them to a boss, the worker may develop bad attitudes and further continue poor practices. Workers can further practice reducing poor practices when gently reminded of how appropriate practices are performed.

8) Why is it important to follow food regulations?

A) So adequate standards are met that are set by the government

B) To protect those that are immune-compromised

C) To know local, state, and federal rules related to your specific produce

D) All of the above reasons are important reasons to follow food regulations

Answer: Regulations must be followed for all of the above reasons. One reason regulations are set is to ensure a quality product to the consumer based off of specific standards. Regulations also serve to protect those that are immune-compromised (this includes the young, elderly, pregnant, and individuals with health issues).

9) Which of the following groups of individuals are more likely to become ill from contaminated produce items?

A) Teenagers

B) Middle-aged people

C) The elderly

D) All are equally likely at becoming ill from contaminated produce items

The elderly are more likely to become ill when consuming contaminated produce items. Teenagers and middle-aged people have developed a fully functioning immune system, which allows their body to fight foodborne illness more effectively. The immune system in the elderly starts to deteriorate over time, making them more susceptible to illness, disease, or death when ingesting foodborne pathogens.

10) What regulation was just modified in 2013 that has given the Food and Drug Administration (FDA) more power than they previously had over produce processors and producers?

A) The Produce Safety Modernization Act (PSMA)

B) The Fruit and Vegetable Regulatory Act (FVRA)

C) The Produce Protection Plan (PPP)

D) The Food Safety Modernization Act (FSMA)

Answer: The Food Safety Modernization Act was signed by president Obama in January 2011. This regulation has been revised since and will be implemented to help reduce foodborne illness in fresh produce.

### **Script of online module:**

To help aid you in your teaching methods, attached below is the script, word-for-word, of what will be spoken during the web based training. By reading the script in advance, you will be able to pause more frequently when you would like to elaborate on certain topics, or stop when you feel is a good break point for your students.

Hello, and welcome to this web-based training about produce food safety on university farms. Because you are involved in production and distribution of produce, it is important for you to follow safe practices while in direct contact with the produce. While normally, we don't consider fresh produce a food item of concern, there have been outbreaks of human illness due to poor production and handling practices on the farm. This module will focus on the biological, physical, and chemical hazards of concern when growing and harvesting produce, and methods we can use to prevent these hazards from occurring. This course is intended to provide participants with an awareness of food safety hazards that can occur on the farm, but is not a substitute of a Good Agricultural Practices workshop.

The goal of this training is to help you understand why safe practices in the field are necessary. The main emphasis during this training is to provide information about all of the potential hazards that may arise in the growing, harvesting and post-harvest handling steps of produce that is usually consumed in fresh form. At each potentially hazardous step, action steps will be recommended to mitigate the risk to ensure safe fresh produce. When you have finished this training, you should have the knowledge and skills to recognize food safety on the farm.

There will be a short recap at the end of each section to summarize the key points to prevent physical, chemical, or biological harm to fresh produce on university farms. The online quizzes will consist of 10 multiple-choice questions.

Foodborne illness is a concern as we work to ensure the safety of fresh produce. The Centers for Disease Control and Prevention estimated that from 1998 to 2008, 46 percent of foodborne illnesses were attributed to produce related items. A majority of these illnesses were linked to lettuce and other leafy greens. In recent years, there have been major outbreaks from other fruits and vegetables, such as cantaloupe, tomatoes, green onions and peppers.

This chart shows fruit/nut and vegetable outbreaks. It breaks down how many outbreaks were due to bacteria, chemicals, and viruses, or a combination of these

agents. This chart helps show that both fruits and vegetables contribute to a significant amount of outbreaks.

Investigations concluded outbreaks occurred due to poor hygiene practices and unsanitary conditions on the farm. Utilizing safety measures while working with produce help prevent outbreaks and result in fewer cases of illness or death.

Numerous microscopic-sized microbial risks may be considered when working with a raw agricultural product, like produce. As humans, our eyes are unable to perceive any objects that are less than 0.1 millimeters in diameter, which is a typical size for many microorganisms. These microorganisms cannot be detected without the use of a microscope. They reside in soil, organic matter, water, or human hosts and are easily transferred to food items. When people eat food with high levels of disease causing microorganisms, they get sick and may even die.

There are different classifications of microorganisms: bacteria, viruses, and parasites. Bacteria are single-celled organisms that live independently in soil, organic matter and water. Some of the most harmful bacteria found in a farm setting are *Salmonella*, *E. coli*, *Shigella*, *Bacillus cereus*, and *Listeria monocytogenes*. Another type of microorganism that can be found on fresh produce are viruses. Viruses are small particles that live and replicate in a host, often humans. Examples of viruses that result in illness are hepatitis A and norovirus. Parasites are intestinal worms that also live in a host. Parasite examples are *Giardia* and *Cryptosporidium*.

In addition to the microbial hazards, there are many physical and chemical hazards that may contaminate produce items and make them unsafe for human consumption. Physical hazards that may be present in the field are glass, wood, and metal. Additional physical hazards in the field could be waste products that were never properly disposed of, including trash bags or empty water bottles left from previous visits.

Chemical hazards in the field include pesticides and herbicides. Improper use of these chemicals and cleaning agents can harm the product and present some physical safety risks. If there is a decision to use these items, they should be used only as directed and only by those who have been trained in their application.

This training breaks down various hazards into four different segments of processing on the university farm. The first section covers microbial, chemical, and physical risks present on the farm. The second is pre-harvest which emphasizes steps to prevent harmful hazard presence during the growing phase.

Third, we will cover post-harvest prevention steps to the various hazards after produce is taken from the field. The segment about good worker practices applies to pre and post harvest and will explain why these are important. Finally, we will discuss the necessary steps to handle, package, and distribute fresh produce as well as cover current regulations in place at local, state and federal levels.

There will now be a short quiz to test your knowledge on overall goals of this training, and why it is necessary. Please stop the training video to complete the quiz.

Welcome back to produce food safety training. The initial steps of produce food safety occur during pre-harvest, which is the time between planting, through the time the crop is harvested from the field. The objective of this section is to understand the various microbial, chemical, and physical hazards that are associated with produce items, and the hazards that arise while the crop is in the field. The pre-harvest portion includes a wide array of steps, from field site selection through harvest.

The first step in preventing contamination from occurring on the field is to follow good agricultural practices, also known as GAPs. Good agricultural practices are any steps taken by the grower or farm worker to protect the product from physical, chemical, or biological hazards. GAPs promote safety but also improve quality. For growers, this is a win-win. Some examples of GAP topics relate to the water, soil, and worker health & hygiene. One specific example of a Good Agricultural Practice is to avoid eating in the garden, which can result in contamination of other produce that is being harvested.

GAPs are necessary for the production of the safest possible produce. Additional information on Good Agricultural Practices is provided in the teaching manual, as well as links to further online resources.

This graphic illustrates the different levels in finalizing a food safety process. Follow these steps to develop the most effective safety system in microbial, chemical, and physical hazard prevention in your field. The first step in developing an effective plan to follow good agricultural practices. A specific example of a Good Agricultural Practice is to test water and ensure potable water is applied for irrigation of the produce. Once GAPs have been developed and implemented, good manufacturing practices, or GMPs, should be developed. GMPs occur in the post-harvest section of produce safety and are applied when the product is being prepared for resale or further use. GMPs prevent microbial hazards from spreading after produce is harvested. Moving up the pyramid, the next two levels are sanitation standard operating procedures, known as SSOPs, and standard operating procedures, known as SOPs. Both of these steps are used to prevent microbial contamination to the product. These documents provide step-by-step instructions of what, how, when, why, and who is to complete each specific task. In these steps, specific chemicals are chosen and used for sanitation of equipment and for the processing facility to ensure that produce is in a clean environment. An example of a sanitation standard operating procedure is proper cleansing and sanitation of equipment that comes in direct contact with the produce items. A standard operating procedure example is proper documentation of the temperature of the product or time the produce was harvested. The final step is the hazard analysis and critical control points, or HACCP plan. This is the final, completed safety plan that addresses any potential hazards in all areas of produce production. Complete development of a food safety plan will protect employees and employers, provide direction and guidance on processing, structure the processing in a specific manner, and will empower people to do the right thing when handling the produce. A HACCP plan will also significantly reduce microbial risks, and will make sure each step of produce processing has all of the appropriate safety measures.

Next, we will discuss the major microbial, chemical, and physical hazards associated with pre-harvest production. The four areas where microbial hazards have the most potential to arise include: water contamination; field and farm location; soil quality; improper usage of manure and biosolids; and potential risks associated with domestic or wild animals in and around the field.

A water source is essential for irrigation and other activities involved in fruit and vegetable production when growing your produce. Typically, there are three types of irrigation water sources – city or municipal water, well water, or surface water. A Rain water and ground water that come to the surface are examples of surface water. Municipal water has already been treated, is potable or safe to drink, and therefore safe to use on the produce. However, well water and surface water require additional tests to ensure safety for use when irrigating or cleaning product. When testing well water or surface water, keep the records for testing. Make sure the water is drinkable as per standard before it is used for watering or washing hands, equipment, or food.

When testing water, a good screening test is for fecal coliforms. Coliforms are bacteria that are found in contaminated water and sometimes make people sick when ingested. Checking for chemical hazards is also an important aspect when working with water. Chemical tests for nitrates are a good idea, as nitrates can be found in water from fertilizers, animal waste, or human sewage.

Never drink from hoses when applying water to the field. Water that has touched your face or mouth can transfer microorganisms to the produce, resulting in contamination.

Flooding is another vital concern during fresh produce production. After a flood, certain pathogens or toxins can enter into the field. Pathogens that can result after a flood include *E. coli*, *Salmonella*, Hepatitis A, and Norovirus. Flooding can help spread these pathogens from localized areas, like a compost pile, throughout the entire garden. All produce that comes in direct contact with floodwater should be discarded, especially food that is to be consumed raw. Raw produce will not have a processing step for the chance of pathogen removal.

The next pre-harvest consideration is the field location and soil properties. Prior use of land and land adjacent to the field will influence the presence of potential hazards. For example, if the field was once an industrial site, the soil could be contaminated. Soil properties and soil treatments will also influence potential microbial, chemical, and physical risks.

After learning about previous land usage, test the soil. These soil samples should be sent to labs that specialize in water testing. Soil testing identifies specific nutrients, which may be lacking in the soil; the current pH of the soils; the class of soil; and potential presence of heavy metals, such as lead. Testing can also indicate high nitrite levels, or harmful microorganisms.

After thoroughly processed, biosolids and compost are great soil supplements for fruit and vegetable production. Biosolids are organic materials that are nutrient rich for fresh produce. Composting is the natural breakdown of leaves, stems, manures and other organic materials. If compost is applied, it should come from a dependable source that can provide an analysis for nutrient content. It is important to calculate the quantity needed for good nutrient management prior to purchasing compost. After application to the field, keep records of the application rates, timing, and specific fields receiving manure or compost treatments.

If raw manure is used, it must be applied at least 120 days prior to harvest. Most importantly, if storing raw manure for the field, keep it in a distant location away from the growing location. If raw manure is held close to the field, there is an increased risk of contamination. If the field is on a slope, the compost should be kept downhill.

The final pre-harvest issue is the presence of animals in or around the growing location. If at all possible, keep all animals, domestic and wild out of the field. When animals are allowed to roam the field, they will defecate, causing produce to come in direct contact with the fecal material. Fecal material contains many bacteria that may cause severe illness. A specific example is *E. coli* 0157:H7. This bacterium has a very low infectious dose, meaning it has the ability to cause illness with very few bacterial cells present.

Many wild animals are carriers of disease, which can result from bacteria, viruses, or parasites. Other than fecal contamination, additional risks to consider are contamination from animals through dirty hair or fur, and unclean paws.

To keep wild or domestic animals away from the growing location, set up physical barriers, such as fences or animal traps. Physical barriers may also prevent vandalism or trespassing.

If physical barriers are not feasible, use various sprays and repellents to keep pests away from the farm. It is a good idea to avoid feeding any wild animals, including birds, near the growing location.

The image on the left shows a hole in the field created by a wild animal. The image on the right shows a path through the middle of a growing field created by deer. To prevent this type of problem and others from occurring, inspect the perimeter of the field frequently to verify all barriers are functional and productive.

In addition to biological hazards, there are many chemical hazards that can arise in the pre-harvest section of produce production. Some common chemicals used, such as pesticides, herbicides, or sanitizers can result in illness. Other potential chemicals that can contribute to illness are allergens that can gain entry into the field. Lastly, there is chemical concern for natural toxins, such as mycotoxins. Mycotoxins are found in rotting apples, and contribute to illness once ingested.

To avoid chemical contamination to produce, train workers to understand the dangers of over-applying pesticides, herbicides, and sanitizers. Only trained individuals should apply these chemicals, and keep them stored in locations away

from the produce. If you are not trained to apply these chemicals, then consult your supervisor. If you are sorting produce for sale, dispose of rotten produce. By disposing of rotten produce accordingly, there will be a reduced chance of harmful chemical agents from the produce.

We have just finished covering the microbial and chemical hazards that can arise during the pre-harvest section of produce processing. The last type of hazard that may occur are physical hazards. These hazards are found in the field and can harm the consumer if found in or on the produce. Different types of physical hazards that can be found in the growing field are metal, glass, wood, stones, or hard plastics.

To reduce the chances of physical hazards from occurring on the field, perform routine inspections of the field. By frequent monitoring, you or other employees can find the harmful physical pieces and remove them from the field as needed. Have trash or waste receptacles close to the field so proper and efficient disposal can occur.

Now, we will summarize what we have just learned about the pre-harvest section of produce food safety in the production fields on a university farm. Remember, an effective food safety plan always starts with Good Agricultural Practices, also known as GAPs. Once GAPs have been implemented, further standards may be applied to reduce risks in other areas of processing. Some additional standards may be Good Manufacturing Practices, Sanitation Standard Operating Procedures, Standard Operating Procedures, and finally, the completed Hazard Analysis and Critical Control Point, or HACCP plan.

The microbial, chemical, and physical hazards that were addressed in the pre-harvest phase of production include: contaminated water source, field location and soil presence, inappropriate usage of compost and biosolids, and domestic or wild animals present in or around the production area. To generate safe, potable water for your field, either use municipal water, or follow disinfection and filtration methods to purify surface or well water. Conduct annual water tests on surface and well water and always keep records of the water tests to document its safety. If planting in a new site, investigate the field location and adjacent land to ensure high land quality and safe soil, and verify the soil through lab testing. Apply raw manure 120 days prior to harvest of produce. To prevent fecal contamination, never store the manure or compost near the growing location. Lastly, take necessary measures to eliminate the presence of domestic or wild animals in or around the production field. Keeping animals from the field will reduce the likelihood of having microorganisms, feces, or potential disease on your produce.

Perform routine inspection on the field to reduce the chances of physical hazards from occurring. By having designated waste receptacles, harmful physical pieces can safely and efficiently be removed from the field.

After reviewing the pre-harvest section of produce food safety, we will now take a short 10-question quiz to test your knowledge over the pre-harvesting section of

this training. Upon completing the quiz, you may proceed to the next portion of the training; post-harvest produce food safety. Please pause or stop the training video.

Welcome back to the produce food safety training. We have just finished covering the safety concerns during crop production and pre-harvest and now will address the post-harvest agricultural practices. Post-harvest processing starts at the point when the produce is harvested from the field. The objective of this portion of the training is to help you understand the various risks associated with post-harvest handling, and action steps that can be taken to resolve the various risks.

A Farm-to-fork food safety approach means products are monitored from the farm all the way through to the point it reaches the consumer. This approach will reduce the risk of contamination from occurring on fresh produce, reducing overall foodborne safety risks. Post-harvest includes cleaning the produce to remove any initial hazards that developed in the field, sorting the produce accordingly, and packaging the produce. It also includes storing it under the right climatic conditions, to maintain high quality and safety levels, and finally transportation and distribution to its destination.

During the post-harvest segment, there are five main areas of concern related to the safety of the food during post-harvest processes. These physical, chemical, and biological hazards are: field harvesting steps and harvesting equipment, sanitation of the facility where the produce is cleaned and packed; methods and practices implemented for waste removal; storage and transportation of the produce; and record keeping to verify acceptable post-harvest practices.

When harvesting in the field, if possible, keep the harvesting bins off of the ground. These containers must be food grade quality to protect the integrity of the product. When bins come in contact with the ground, they can pick up harmful microorganisms found naturally in soil, in addition to any potential fecal material from wildlife or birds. Once the produce has been harvested and transported, clean the harvesting bins after every use. This will remove any dirt or debris that is collected while harvesting and remove any microorganisms that may be present from rotting or spoiled produce that was previously harvested.

Cleaning procedures will vary depending on the item. Some produce can be brushed, like squash, whereas others may simply be taken to market as harvested, like strawberries. Other products may require one or two washing.

When rinsing the produce with potable water, the water should be no more than 10 degrees warmer than the produce item. Do not wash berries, such as strawberries, raspberries, blackberries and blueberries.

Another post-harvest concern is the sanitation of the location where the produce is taken after harvest for cleaning and packing. Cleaning means the product is free of any visible soil or other materials, while sanitation means there is a reduction of harmful microorganisms to low enough levels to which they cannot cause harm.

When harvesting, make sure to take each steps into consideration (culling of



defective products, use of clean and sanitary totes, removal of physical soil, and a second sanitizing wash if appropriate). Make sure the equipment and all work surfaces that come in contact with the produce are clean and sanitized. Cleaning and sanitizing will reduce the chance of cross-contamination from equipment to the final product.

Some spoilage and rotting is common when harvesting produce. When spoiled crops are found in the field, dispose of it in a compost pile or designated location away from the field. If waste is removed appropriately, bacterial and mold growth will not be able to spread to healthy produce, and other physical waste materials will be unable to contaminate the growing fruits and vegetables.

Wastewater is another aspect of disposal that needs to be addressed. When disposing of wastewater, move the water away from the washing and packing areas to keep a sanitary working environment.

Once the produce is harvested and thoroughly cleansed with safe water, it must be stored appropriately. Improper storage will increase microbial growth on the produce. For inventory and product quality control, it is best to practice the, "First in, First out" system. Following "First in, first out" will reduce the likelihood of spoilage and microbial growth.

The storage area should be at the proper temperature and humidity for the specific produce item. Maintain records and monitor the temperature and humidity frequently to ensure that appropriate environmental conditions are met. Nothing should be stored on the floor due to contamination risks.

Storage temperature has a significant impact on microbial growth and survival on produce. Some products must be stored at refrigeration temperatures. When these products are stored at higher, undesirable temperatures, the microbial population increase is favored. Refrigeration temperature is dependent on the specific produce item.

The storage facility must be pest-free; a well-ventilated area for storage is also required to allow proper airflow in and out of the storage location. Do not store any produce near household chemicals to avoid accidental contamination.

The next step of post-harvest handling is produce transportation. Our primary concern in transportation is from the field into the processing facility. When transporting the produce, keep it well covered to avoid contamination from debris, or fecal contamination from birds.

It is extremely important to always keep record of the produce that leaves the farm. The documentation should include where the produce was grown and harvested, the name of the harvester and the amount of product that was distributed, and where it went. These actions enable you to have complete records for traceability. The more controls you have implemented, the less chance of allowing a contaminated batch of produce from leaving the farm.

Now is time to discuss the chemical hazards that can occur in the post-harvest section of produce processing. In addition to the herbicides and pesticides listed earlier in pre-harvest, there are other chemicals that are used during the processing of produce. Some of the chemicals that are used in post-harvest handling are: pest control chemicals, cleaners and sanitizers, detergents and lubricants, and chemicals that are used to disinfect water. If any of these chemicals are used incorrectly or are applied from poor employee practices, they can result in illness to the consumer.

To minimize the risk of chemical contamination, do not use more of the chemical than specified on the label. Only use chemicals for their specific purpose. Applying chemicals inappropriately can cause harmful chemical agents to interact with the produce. And when storing chemicals, keep them away from the produce. Chemical containers can become damaged and leak. The chemicals can spill onto produce, resulting in contamination.

Much like pre-harvest processing, there are many physical hazards that can occur in the processing of produce. To minimize physical hazards from occurring during post harvest processing, perform physical examination of the produce.

It is now time to take a short, 10-question quiz over the post-harvest section of produce food safety training.

In this section of produce food safety training, we will emphasize the importance of good employee practices and current regulations, associated with food safety. The objective is to understand the potential risks that can arise from employee practices, and what measures must be taken to prevent the spread of microorganisms.

A significant amount of produce contamination can be attributed to poor employee training. Harmful bacteria from the employee have the ability to contaminate the product. Contamination can occur from improper hygienic practices from the employee, previous interactions with objects, such as door handles, and inappropriate sanitation and cleansing of tools and equipment used in the handling and packing facility.

Improper hygienic practices can happen at work or at the home. Do not go to work if you show signs of diarrhea, vomiting, or sore throat. Microorganisms can pass through the sick individual to the produce item, with potential to spread to the overall batch of produce. It is imperative to wear clean clothes when going to work, and wash clothing daily when returning from the handling and packing area. In addition to these measures, do not eat in the packing areas. This will remove the opportunity for physical hazards to enter this area. Lastly, hygienic practices should always be followed by a thorough hand washing, prior to handling the produce. It is also very important to avoid direct contact of bodily fluid with the fresh produce items, including urine, blood, and saliva. Workers can transfer diseases, including hepatitis A, if a healthy individual ingests the blood. Other illness or disease can occur if saliva from the worker's mouth is transferred to the fruits and vegetables. It

is essential to inform workers that coughing and sneezing should be contained and not spread to the products being harvested.

To prevent increased illness, wash your hands with warm water and soap. At your field, always provide clean and convenient restrooms for customers and employees that will be harvesting. These restrooms should have all the necessities for the appropriate 6-step hand washing method. To avoid bodily fluid contamination, train workers to report any potential bodily fluid contamination. If contamination occurs, the product should be disposed in the correct manner. During this training, it is important to also inform the workers how to appropriately cough or sneeze when working in the garden or field to prevent cross-contamination via saliva.

The U.S. Centers for Disease Control and Prevention estimates that over 50% of foodborne illnesses are linked to poor hand washing practices. They say, “Hand washing is the single most important means of preventing the spread of infection.”

Wear clean, non-tattered clothing to work on the farm. If shaggy, shredded clothing is worn, buttons or other physical pieces may fall off onto the clean product. These physical pieces can potentially cause physical hazards. If ingested by the consumer, they may choke on them. If operating mechanical equipment, these physical pieces may get stuck in the machinery and cause further harm to the worker.

There are a few different ways to help reduce improper hygienic practices. Make sure that employees that are in direct contact with the produce meet the specific qualification and have taken all the training courses to be aware of cross-contamination. Once training has been taken, make sure it was properly documented. It is important to retake training classes to keep up-to-date on safety changes. Frequent training will also help you remember important concepts that may be forgotten on a daily basis. And most importantly, ALWAYS wash your hands thoroughly.

Another form of cross-contamination occurs from fomite interactions and improper cleansing of harvesting tools. A fomite is an inanimate object that promotes the spreading of microorganisms from one place to another. Toilet seats, doorknobs, and cell phones are all examples of fomites. Avoid all potential fomite interactions when in contact with produce. As an added barrier, wear disposable gloves when in direct contact with the produce and when completed, dispose of the gloves in a designated receptacle.

In this last portion of the training module, we will discuss why food regulations are important. Regulations are specific rules that are implemented by the government and must be followed.

Regulations play a critical role in produce food safety. These rules help protect individuals from becoming ill from contaminated food. Regulations specifically protect infants, the elderly, pregnant women, and immune-compromised

individuals. Infants are at risk because they have not developed a fully functioning immune system. The elderly are at high risk because they are losing function of their protective barriers. Pregnant women are also more susceptible to foodborne illness, because they have to share some of their microbial barriers with the growing fetus. Immune-compromised individuals have never had a completely functioning immune system. They have a lower tolerance when in contact with harmful microorganisms.

Federal, Statewide, and local regulations must be followed. Depending on the specific venue of the product, regulations will vary.

## **Additional exercises:**

### **Additional exercise #1: What's wrong with the bathroom?**

#### **Educational requirements for Activity #1:**

- General biology concepts.
- General knowledge of proper hygiene in the restroom.

In this activity, students will be tested on what needs to be present in the restroom for proper hygienic practices to occur.

To successfully complete this activity, students will need writing utensils and the printed off worksheets from the “Activity” tab to the right of the module video. This worksheet will show a graphic of what a typical bathroom may look like when working in the field. Students will be required to circle the parts of the restroom that look incorrect and write an explanation for why they believe the restroom isn't providing adequate material for proper hygienic practices.

This activity should help reinforce the main areas where cross-contamination can occur after restroom usage.

Below is the answer key of the activity, with explanations for why each circled portion is an example of hazard.

### **Additional exercise #2: What Would YOU do?**

#### **Education requirements for Activity #2:**

- General biology concepts.
- General chemistry concepts.
- Situational critical thinking.

This exercise will also be available in the “Activities” tab to the right side of the module. In this activity, students will receive two short case studies of different people working in the field. Each case study will emphasize different areas of improper practices in the field. After reading the case studies, students will be expected to identify all of the hazards in each study, explain what each hazard is in

each study, and what should be done to reduce risk or prevent the hazard from occurring. Upon completion of this case study, a majority of the hazards listed throughout this module will be addressed. Students should have most safety concepts reinforced prior to entry onto the field.

Below is the answer key for all of the hazards listed in the three case studies provided.

### Case Study 1:

#### What would YOU do?

Read the following case study to see what was done incorrectly, and how changes can make the garden a safer place.

Allison woke up with a sore throat on Tuesday morning. Not feeling very well, she decided to go to work and harvest fruits and vegetables. Once arriving at the field, Allison stepped into the garden with close-toed shoes, and started picking produce. Right as she entered the field, Allison heard her pet dog, Heidi, barking for attention. Allison decided to open the gate to the field and let Heidi walk around with her as she continued to pick the produce.

By the time she got to the middle of the field, Allison was extremely thirsty due to her sore throat. Not bringing any water into the field, she glanced down at the gardening hose and took a quick drink out of it.

While she was placing the produce items in the harvesting bins, Allison was receiving a phone call on her cell phone. Excited for the concert she was attending tonight, she decided to pick up her phone and plan the rest of the night's events.

As Allison was walking out of the field with her dog, she spotted a broken glass bottle by one of the crops. Since she still had to take her produce items to post-harvest production, she walked past it with her harvesting bin.

Allison had been picking room temperature produce items. Once it was ready for storage, she put it in a pest-free, well ventilated location on the ground by the pesticides and sanitizers.

The last thing Allison did before finishing for the day was sanitize the post-harvest production facility. She made stronger concentrations than recommended on the back of the container because this will help kill more potential hazards than what was suggested on the bottle. Allison then left the sanitizers to air dry and went home to plan the rest of her evening.

#### 1. What did Allison do wrong?

--- Allison had a sore throat before even going to work. When showing signs of diarrhea, vomiting, or sore throat, do not go to work.

---She let her dog, Heidi enter the field. Both domestic and wild animals should be kept out of the field as much as possible.

---Allison drank out of the hose. NEVER drink out of hoses. This can spread illness to from her mouth to the water, and then to the produce.

---She answered her cell phone while working in the field. Cell phones can be a potential fomite, which can allow the transfer of harmful microorganisms from Allison's hands and make safe produce items unsafe.

--- Allison saw broken glass in the field and decided to leave it for someone else to take care of. When physical hazards are seen, they should be taken care of immediately, in a safe manner.

---Allison stored the room temperature produce by pesticides and sanitizers. To reduce the chances of chemical hazards from occurring, never store chemicals by produce items.

---She used stronger concentrations of sanitizer than recommended on the label. By not following the directions on a label, a chemical hazard can result from excess chemical usage.

## 2. What can YOU do to avoid these problems?

--- DO NOT go to work if you have symptoms of diarrhea, vomiting, or sore throat. Call in to your supervisor and tell them you are unable to work.

---Never let domestic or wild animals into the field. This will reduce the likelihood of spreading disease or fecal contamination to the produce items.

---Never drink out of hoses. Drinking from hoses will aid in spreading potentially harmful microorganisms from your mouth to the soil, crops, or produce items.

---Do not bring cell phones or other potential fomites into the field with you. If contact is made with anything other than the fruits or vegetables, make sure to properly wash hands before AND after contact is made with the object.

---Dispose of any physical hazards in a safe, appropriate manner. The physical hazards should be moved to a proper waste receptacle and removed from the garden in a timely manner.

---Keep chemicals in a distant location from where all produce will be stored. Chemicals should be kept in a locked, secure location to avoid and tampering or inappropriate application. Only certified individuals should use the chemicals.

---Only use the recommended amount of sanitizer as stated on the label. A lack of sanitizer may not eliminate all the potential microorganisms present, while too much chemical could result in a chemical hazard itself.

## Case Study 2:

### What would YOU do?

Read the following case study to see what was done incorrectly, and how changes can make the garden a safer place.

Josh woke up feeling very well and ready to work this Thursday. After getting ready, he went to work and ready to pick some fruits and vegetables from the field. As he arrived, Josh walked into the field in his sandals and started picking the produce. Josh left his harvesting bin on the ground because he didn't have a vehicle or bench to put it on.

By the time he got to the middle of the field, Josh had to use the restroom very badly. He walked into the portable restroom available. There was not soap present, so he

just decided to rub his hands on his shirt and go back to picking the fruits and vegetables.

Earlier in the shift, Josh's boss informed him that pesticides were applied to the field prior to his arrival. Josh remembered that the chemical containers were on the other side of the field. He decided that he could leave them in the garden for the night and would pick them up tomorrow when he returns. As Josh was leaving the garden, he saw some rotten tomatoes on the ground by the other fruits and vegetables. He decided to leave them where they were so the nutrients from the tomatoes could benefit the soil.

Once the produce got to post-harvest production, Josh put the refrigerated produce in the refrigerator. When it was time to continue production, he removed the most recently refrigerated produce items from storage to continue the processing steps. Josh did not take any records of temperatures, storage times, dates, or cleaning and sanitizing practices.

### 1. What did Josh do wrong?

---Josh wore sandals in the field. Wearing sandals will increase the risk of a physical hazard to occur.

---He stored the harvesting bin on the ground, rather than on a bench or vehicle. These should not be stored on the ground because potentially physical, chemical, or microbial hazards can come in contact with them from the soil and contaminate the produce.

---He didn't wash his hands appropriately. ALWAYS wash hands with soap and water and lather for 15 seconds, and dry with a single use disposable towel.

---Josh left chemicals in the field overnight. Chemicals should not be left in the field or unsupervised at any time. These chemical containers could leak, resulting in a chemical hazard in the soil or on the produce itself.

--- Josh left the rotting produce in the field. These fruits and vegetables should be removed from the garden and placed in a proper waste location or compost. The rotten produce will favor microbial growth and can potentially contaminate the soil with harmful or spoilage microorganisms.

---He removed the most fresh produce items first. Josh should follow the "First in, first out" protocol to maximize produce output and reduce waste.

---Josh didn't take any records. Records need to be taken to make sure produce is handled appropriately and safely.

### 2. What can YOU do to avoid these problems?

--- Always wear closed-toed shoes when going to work in the garden. By wearing appropriate footwear, the chances for a physical hazard to occur are significantly reduced.

--- Bring a vehicle or bench to store harvesting bins on. The vehicle should have a covering over the harvest baskets to reduce the chance of bird feces or dirt and debris from entering.

- Always follow the appropriate protocol when washing hands. Rinse hands with water, lather them for 15 seconds (making sure to wash the hard to reach areas), wash off residual soap, and dry hands with a disposable hand towel.
- Store chemicals in a location away from the produce. Make sure the chemicals are kept in a locked location where only certified personnel can access them to reduce chances of chemical hazards from occurring.
- Properly remove rotting or decomposing produce from the field. Place these items in a designated waste area (a garbage or a compost for use at a later time).
- Follow the “First in, first out” protocol to reduce waste with produce items.
- Always keep documentation. If you didn’t record it, IT NEVER HAPPENED! Be as specific as possible when taking qualitative data. With quantitative data, it is very important to take dates, times, temperatures, pH values, etc. The more elaborate you are, the better the documentation will be.



**Risk Management:**

As illustrated throughout the teaching manual and module, there is a wide array of hazards that employees are exposed to in pre-harvest and post-harvest areas of produce processing.

Before having employees enter the field, make sure there is a fully stocked first aid kit that is readily available if any form of accident were to occur while they are working. This first aid kit should include a minimum of: Bandages, adhesive tape antibiotic ointment packs, aspirin, two pair of latex gloves, scissors, sterile gauze pads, and tweezers. If any of these materials are used for injuries on the field, make sure to properly restock the first aid kit for any potential injuries that could occur in the future.

Besides the first aid kit, make sure to always have a cell phone readily available in case serious injury was to occur. Keep medical phone numbers on hand if needed. Make sure to have the local hospital number on hand if needed. For chemical hazards, make sure to have the poison control number ready in case of potential ingestion or exposure to harmful chemicals.

Have at least two emergency contacts from each employee in case some injury does occur.

## References:

General comprehensive resources for garden food safety:

- <http://www.extension.iastate.edu/hrim/localfoods>
- <http://extension.psu.edu/food/safety/farm/gaps>
- [http://www.schoolnutrition.org/uploadedFiles/School\\_Nutrition/104\\_CareerEducation/ContinuingEducation/Webinar\\_Wednesdays/GAPs%20School%20Gardens-11.3.11%20FINAL%20UPDATED.pdf?n=8068](http://www.schoolnutrition.org/uploadedFiles/School_Nutrition/104_CareerEducation/ContinuingEducation/Webinar_Wednesdays/GAPs%20School%20Gardens-11.3.11%20FINAL%20UPDATED.pdf?n=8068)
- [http://www.schoolnutrition.org/uploadedFiles/School\\_Nutrition/104\\_CareerEducation/ProfessionalDevelopment/Certification/Cerification\\_Documents/Food%20Safety%20Tips%20for%20School%20Gardens.pdf?n=7984](http://www.schoolnutrition.org/uploadedFiles/School_Nutrition/104_CareerEducation/ProfessionalDevelopment/Certification/Cerification_Documents/Food%20Safety%20Tips%20for%20School%20Gardens.pdf?n=7984)
- [http://www.wafarmtoschool.org/Content/Documents/School\\_Gardens\\_Food\\_Safety\\_Tips\\_-\\_Maryland\\_Extension.pdf](http://www.wafarmtoschool.org/Content/Documents/School_Gardens_Food_Safety_Tips_-_Maryland_Extension.pdf)
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- <http://www.sde.ct.gov/sde/LIB/sde/pdf/DEPS/Nutrition/OPmemos/10/5stepsOM1010.pdf>
- <http://www.cde.ca.gov/ls/nu/he/gardensafety.asp>
- <http://ucfoodsafety.ucdavis.edu/files/157441.pdf>
- <http://wwwnc.cdc.gov/eid/article/19/3/pdfs/11-1866.pdf>
- <http://agriflifefoodsafety.tamu.edu/files/2011/03/Pre-Harvest-and-Harvest-Food-Safety.pdf>
- [http://s3.esoft.com.mx/esofthands/include/upload\\_files/4/Archivos/7%20Contamination%20hazards%20in%20fresh%20fruits%20and%20vegetables.pdf](http://s3.esoft.com.mx/esofthands/include/upload_files/4/Archivos/7%20Contamination%20hazards%20in%20fresh%20fruits%20and%20vegetables.pdf)
- <http://www.rhs.org.uk/Children/For-families/Safety-tips>
- <http://www.maricopa.gov/publichealth/Services/Nutrition/Garden/pdf/minimizing-microbial-food-safety-hazards-in-the-school-garden.pdf>
- [http://pubs.ext.vt.edu/FST/FST-60/FST-60\\_PDF.pdf](http://pubs.ext.vt.edu/FST/FST-60/FST-60_PDF.pdf)
- <http://ucanr.org/freepubs/docs/8366.pdf>
- <http://www.fao.org/docrep/009/ae075e/ae075e23.htm>
- <http://www.fda.gov/downloads/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/ProduceandPlanProducts/UCM169112.pdf>

## APPENDIX C: CASE STUDIES FOR ELEMENTARY MODULE

**What would YOU do?**

Read the following case study to see what was done incorrectly, and how changes can make the garden a safer place.

Little Susie rinsed her hands thoroughly with soap and water before going out to the garden to pick fruits and vegetables. Susie entered the garden wearing her sandals and her basket and began picking produce that was ready. As she was harvesting, Susie saw a broken glass bottle in the garden. She safely stepped over it and continued picking the produce.

After awhile of picking produce, Susie was feeling very thirsty. She looked around the garden and saw the garden hose. She went over to it, turned it on, and took a quick drink from the hose.

When Susie finished in the garden, she gave the produce to her teacher to put in a safe place. She then washed her hands under the sink for two seconds before going back to class.

1. What did Susie do wrong?

2. What can YOU do to avoid these problems?

## What would YOU do?

Read the following case study to see what was done incorrectly, and how changes can make the garden a safer place.

Brian washed his hands with soap and water before going out to pick fruits and vegetables. He tied his shoelaces tightly, and went into the garden to pick the produce.

Brian saw some gardening tools outside of the garden, so he decided to use them on some of the produce items as he went around collecting fruits and vegetables. When finished with the tools, Brian set them down in the garden and went back to picking. After picking produce for some time, Brian heard the class puppy, Scrappy, barking at the gate of the garden. Feeling bad for Scrappy, Brian opened the gate to the garden to let Scrappy walk around the garden while he picked the fruits and vegetables.

When Brian finished picking the fruits and vegetables, he left the basket by the entrance to the garden and went inside to wash his hands with soap and water.

1. What did Brian do wrong?

2. What can YOU do to avoid these problems?

## APPENDIX D: CASE STUDIES FOR UNIVERSITY MODULE

## What would YOU do?

Read the following case study to see what was done incorrectly, and how changes can make the garden a safer place.

Allison woke up with a sore throat on Tuesday morning. Not feeling very well, she decided to go to work and harvest fruits and vegetables. Once arriving at the field, Allison stepped into the garden with close-toed shoes, and started picking produce. Right as she entered the field, Allison heard her pet dog, Heidi, barking for attention. Allison decided to open the gate to the field and let Heidi walk around with her as she continued to pick the produce.

By the time she got to the middle of the field, Allison was extremely thirsty due to her sore throat. Not bringing any water into the field, she glanced down at the gardening hose and took a quick drink out of it.

While she was placing the produce items in the harvesting bins, Allison was receiving a phone call on her cell phone. Excited for the concert she was attending tonight, she decided to pick up her phone and plan the rest of the night's events.

As Allison was walking out of the field with her dog, she spotted a broken glass bottle by one of the crops. Since she still had to take her produce items to post-harvest production, she walked past it with her harvesting bin.

Allison had been picking room temperature produce items. Once it was ready for storage, she put it in a pest-free, well ventilated location on the ground by the pesticides and sanitizers.

The last thing Allison did before finishing for the day was sanitize the post-harvest production facility. She made stronger concentrations than recommended on the back of the container because this will help kill more potential hazards than what was suggested on the bottle. Allison then left the sanitizers to air dry and went home to plan the rest of her evening.

1. What did Allison do wrong?

2. What can YOU do to avoid these problems?

## What would YOU do?

Read the following case study to see what was done incorrectly, and how changes can make the garden a safer place.

Josh woke up feeling very well and ready to work this Thursday. After getting ready, he went to work and ready to pick some fruits and vegetables from the field. As he arrived, Josh walked into the field in his sandals and started picking the produce. Josh left his harvesting bin on the ground because he didn't have a vehicle or bench to put it on.

By the time he got to the middle of the field, Josh had to use the restroom very badly. He walked into the portable restroom available. There was not soap present, so he just decided to rub his hands on his shirt and go back to picking the fruits and vegetables.

Earlier in the shift, Josh's boss informed him that pesticides were applied to the field prior to his arrival. Josh remembered that the chemical containers were on the other side of the field. He decided that he could leave them in the garden for the night and would pick them up tomorrow when he returns. As Josh was leaving the garden, he saw some rotten tomatoes on the ground by the other fruits and vegetables. He decided to leave them where they were so the nutrients from the tomatoes could benefit the soil.

Once the produce got to post-harvest production, Josh put the refrigerated produce in the refrigerator. When it was time to continue production, he removed the most recently refrigerated produce items from storage to continue the processing steps. Josh did not take any records of temperatures, storage times, dates, or cleaning and sanitizing practices.

1. What did Josh do wrong?

2. What can YOU do to avoid these problems?

## APPENDIX E: INTERACTIVE GRAPHIC FOR ELEMENTARY MODULE



## CHAPTER 4: EVALUATING ONLINE FOOD SAFETY CURRICULUMS THROUGH A PILOT STUDY FOR UNIVERSITY FARMS AND SCHOOL GARDENS

### Introduction

There is continued concern with foodborne illness associated with fresh produce. Human pathogens are able to survive and reside on the surfaces of fresh produce items (Harris, 2003). Human illness has increased in the United States over consumption of raw produce items (Beuchat, 1997). Illness in fresh fruits and vegetables are a major concern in produce items, with 46% of total reported foodborne disease attributed to fresh fruits, vegetables, and nuts (Painter, 2013).

Food safety courses are currently being offered from many different academic institutions, in many different locations to reduce the risk of foodborne illness from fresh produce. North Carolina State University, for example, is currently offering in-person training programs for food safety industry workers, which include workshops with focus on Good Manufacturing Practices (GMPs), and HACCP training courses. They also offer additional online food safety training material, including college coursework and short courses, with focus on GMPs, proper sanitation, with online HACCP courses offered (NC State University, 2015). There are many additional university extension websites available online that provide food safety tips and facts for school gardens such as University of Minnesota, Oregon State University, and University of Massachusetts. Each program offers various on-site training and many online printed resources that can be applied to working in school gardens or on university farms. Our program was designed to provide the workers of these two demographics with a one hour online



program that is cost efficient, time efficient, and that can address basic hazard and hazard prevention techniques when working with fresh produce.

The online platform has shown many benefits in many courses. Online learning can be viewed multiple times, giving students or farm workers the opportunity to review content as needed. They allow for viewers to be flexible with their time (Hammonds, 2003). Programs available have already shown to be convenient, efficient, and affordable (Neal, 2010). One main benefit of online education is that it is very accessible to its users. The participants are able to view all information, whenever free time allows. It also promotes individual learning and accountability (Coyner & McCann, 2004). Online learning allows school garden teachers to designate classroom time for partial training one day, and completing the training when additional class time is available. Lastly, online learning can offer multimedia activities that can motivate students (Mupinga, 2005). Online trainings have already been developed in other food areas to educate employees on safety hazards that can arise in their specific industries (Beffa-Negrini, 2007).

The goal of this project was to pilot our 2- one hour food safety programs (school gardens and university farms) to determine if knowledge could be changed after viewing online developed materials. Our pilot study included retention quizzes that were given before and after participants viewed the developed content, to evaluate knowledge increases after viewing. Knowledge increases are an important aspect to consider when training employees because they have been shown to be a potential precursor to behavioral changes. A change in behavior for school and university farm workers can help reduce foodborne disease risk in produce harvested from each location. Ajzen

(1991) proposed a theory called the theory of planned behavior. This theory states that attitudes toward behavior (as well as subject norm and perceived behavioral controls) shape behavioral intentions and behaviors. Relating this theory to food safety, long-term behaviors may change when exploring attitudes, norms, and intentions of food workers (Roberts et al., 2008).

## Methodology

### **Development of online curriculums for food safety pilot study**

#### Development of online videos

Two online training modules were developed to educate workers of school gardens and university farm workers on food safety hazards that can be encountered when working in gardens or on farms. The elementary module was divided into four individual sections. Section one (Introduction and importance of fresh produce) focused on importance of fresh produce in the diet and importance and risks associated with improper handling of fresh produce. Section two (Pre-harvest hazards and prevention methods) emphasized pre-harvest hazards associated with fresh produce and pre-harvest hazard prevention. The primary focus of section three (Post-harvest hazards and prevention methods) was on post-harvest hazards and prevention methods to reduce risk of foodborne illness after harvesting fresh produce. The final section (Good handling practices, personal hygiene, and proper storage practices) focused on good handling practices, proper personal hygiene, and proper storage of fresh produce during post-harvest production.

The university module was divided into five separate segments. The first section (Introduction and importance of produce safety training) emphasizes the importance and

knowledge that can be gained from an online comprehensive training. The second segment (Pre-harvest hazards and pre-harvest hazard prevention) focuses on physical, chemical, and biological hazards associated with pre-harvest production of fresh produce. The importance of good agricultural practices and good handling practices during transportation production of fresh produce during post-harvest was emphasized in section three (Good Agricultural Practices and Good Handling Practices). The fourth section (Personal hygiene and cross-contamination risks) has focus is on proper personal hygiene and preventative measures to reduce the risk of cross-contamination to fresh produce. The final section (Regulations associated with fresh produce) in the university module goes into regulations, variations in regulations based on geographic location and the specific market the produce is distributed to, and updated information on FSMA and updated regulation changes.

User manuals provide the instructors with answers to all supplemental information and additional references for each section of training. Two case studies were developed for each module, with focus on identifying food safety hazards in school and university gardens and hazard prevention techniques.

#### Expert Steering Committee

An expert steering committee was formed and utilized to edit the developed content and to verify all material was appropriate for each age group prior to conducting the pilot study. The committee was comprised of six individuals that work directly with school, community, or university growers. Committee members had a wide range of expertise, including food safety specialists, a horticulture expert, and a non-profit school employee. Meetings were held three times over a year to aid in the development,

organization, and additional modification of the modules. Oral, written, and survey feedback was taken from the committee during module development; modifications and additions were implemented into each portion of the developed material for both training modules.

#### Development of Supporting Material

After development of modules, case studies, scripts, and instructor supplemental manuals, the developed material was reviewed by a steering committee for further feedback or changes. Supplemental material used after viewing online training videos included ten point multiple-choice quizzes for each module section, a user manuals for instructor convenience, case studies, and an interactive graphic highlighting major food safety hazards observed in school gardens. Figure 1 is a composite list of all quiz questions asked from the elementary module sections, and figure 2 if a list of each quiz question asked in each section of the university module. Multiple-choice questions were divided based on the specific section of the module over information provided to the viewer from online training.

#### Effectiveness Survey

Following committee approval and changes of online development, a pilot study was performed over the online curriculum and was evaluated by students and staff at two k-12 schools in Iowa and two land grant universities. Our team was granted an Institutional Review Board (IRB) approval through the Office of Responsible Research at Iowa State University (1/3/2014 IRB ID 13-598). An exemption to pilot both 1-hour modules at schools and universities with an instructor present was given. Instructors of

the online curriculums provided additional feedback on module layout, content, and suggestion for improvement after performing the pilot study.

### Statistical Analysis

Analysis was performed using SAS 9.3 to determine significant knowledge increases when comparing pre-knowledge and post-knowledge quizzes for both demographics. Pairwise comparison t-tests were performed to evaluate pre-knowledge and post-knowledge quiz scores for individual module sections in elementary and university online trainings. A 95% confidence was used to evaluate pre-knowledge and post-knowledge quiz results for each module population.

### Results & Discussion

Table 1 provides pre-knowledge and post-knowledge mean scores of 1<sup>st</sup>-3<sup>rd</sup> grade students (n=26) and 6<sup>th</sup>-8<sup>th</sup> grade students (n=17) to evaluate knowledge gains immediately before and immediately after viewing the online curriculum. Significant knowledge increases were observed in 1<sup>st</sup> – 3<sup>rd</sup> grade students in each module section after viewing the developed content ( $P < 0.05$ ). Mean scores for 6<sup>th</sup> – 8<sup>th</sup> grade students also increased in all sections after viewing the developed material ( $P < 0.05$ ). There were no statistical differences observed between the 1<sup>st</sup> -3<sup>rd</sup> and 6<sup>th</sup> – 8<sup>th</sup> grade students when placed together ( $P = 0.25$  Pre-Knowledge, and  $P = 0.74$  Post-Knowledge).

Table 2 shows pre-knowledge and post-knowledge mean scores of university farm workers from two land-grant universities ( $n_1 = 14$ ,  $n_2 = 11$ ). University farm results showed a significant knowledge increase in each module section of the developed material, with the exception of section 4 ( $P < 0.05$ ). The only section of the university module that showed no significant differences in pre-knowledge and post-knowledge was

the section dedicated to post-harvest handling and personal hygiene practices. No differences in this section could mean that our sample populations have already had knowledge in this specific area of produce food safety.

Quiz scores prior to viewing online content were higher than expected in both elementary garden and university farm modules. There were no differences observed between the two university farms surveyed in the knowledge gained ( $P=0.43$ ). These results suggest that there are no geographic barriers impacting prior knowledge or knowledge gained from viewing the developed material. There were also no significant differences observed when comparing pre-knowledge material with both elementary age groups, suggesting that the material developed was appropriate for both age groups viewing the online training.

Other studies have been performed to test the efficacy of school gardens on knowledge, attitudes, and behaviors toward students using Good Agricultural Practices with fresh produce in an online learning environment. Leary and Berge (2006) state that electronic learning has continually improved how agriculture education is performed. Online learning can help bring together farmers, researchers, and agriculture experts to help bridge the gap of produce food safety learning. Within our study, survey results found knowledge increases for both populations after viewing the developed material. Elementary students were more knowledgeable in the importance of fruits and vegetables in the diet, where pre-harvest hazards occur and how to prevent them from occurring, where post-harvest hazards may arise and how to prevent them, and good handling and storage practices after harvesting produce. University farm workers showed increases in knowledge in pre-harvest hazards and hazard prevention, how to use Good Agricultural

Practices and Good Handling Practices to prevent pre-harvest hazards, and knowledge of currently updated regulations associated with fresh produce.

This research has found similar results to those of other studies, showing increased exposure and training to fresh produce will increase knowledge, resulting in behavioral changes over time. Online problem based learning courses have also shown to have an increase on overall critical thinking skills for students (Şendağ, 2009). Web-based programs have proven to challenge students similarly to traditional classroom learning, allowing for an equally effective learning experience as face-to-face interaction with instructors. Benefits to online learning include reduced cost of time and travel, an efficient and effective training of participants, and reduced session time to complete training (Evans, 2001). Each module our team created can be completed in under an hour, saving time for participants and instructors of the online curriculum. All benefits mentioned can be observed in our online curriculum. The online training programs will be administered with an instructor present, allowing for students to get further clarification or understanding of material presented. Based on instructor discretion, additional activities and quizzes can be administered individually or in a small group environment, which can enhance learning through small group activities or full class involvement. Lastly, the training curriculum was developed online to allow instructors to pause training at specific points, allowing for additional questions from the viewer.

In addition to increasing knowledge of hazards in and around the garden, viewing the developed material may help students change attitudes and behaviors toward fresh produce consumption, reducing obesity. Additionally, changing behaviors can improve daily practices while in or around the garden, reducing cross-contamination and the risk

of foodborne illness. Morris (2002) performed a study to test fourth grade knowledge on nutrition. Results showed that including a garden-based curriculum is successful in improving nutritional knowledge of children. Incorporating our curriculum into schools can inform students on the benefits of fresh produce in their diet, resulting in a healthier eating behavioral change. One limitation to this research included the total sample size for each pilot evaluation. This study included results from two elementary schools in Iowa and two land-grant universities. Including more schools and universities across the country would give a better representation of nationwide produce food safety pre- and post- knowledge.

### Conclusion

This project has been successful in developing two online fresh produce food safety modules that have increased knowledge in elementary gardens and university farms. This pilot study has shown:

- 1) Significant knowledge increases can occur in online education programs in school garden and university farm settings.
- 2) Module content and additional activities are appropriate for each population tested.
- 3) The developed online modules and additional activities are understood equally in different geographic regions, allowing for further distribution for distance education programs.

Statistically significant results showed increased knowledge in both populations tested when comparing pre-knowledge and post-knowledge quiz scores. Viewing the developed online trainings provide participants with important information to reduce the



risk of foodborne illness from occurring on fresh produce items in school garden and university farms. Long term behavior and knowledge retention will be measured over the next year production.

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Quiz questions for elementary section one of online module

- 1) Why is it important for us to eat fruits and vegetables?
- 2) What will eating fruits and vegetables help do?
- 3) What is this diagram called?
- 4) About how much of the food we eat should come from fruits according to this diagram?
- 5) About what percent of our food should be made up of vegetables according to this diagram?
- 6) What will make a difference to you when you decide how many fruits and vegetables to eat each day?
- 7) What should be done to make sure people don't get sick from eating contaminated fruits and vegetables?
- 8) What is a good food to eat to stay fit and healthy?
- 9) Why are we learning about gardening?
- 10) Why is it important for us to do everything we can to keep the fruits and vegetables safe?

Quiz questions for elementary section two of online module

- 1) What are the three ways that can make us sick or hurt us when in the garden?
- 2) What does the term, "microorganism" actually mean?
- 3) What are three types of microorganisms that might make people sick if present on the food they eat?
- 4) What are the names of some bacteria that could be harmful to people if eaten?
- 5) What is the most common and harmful type of virus related to produce?
- 6) Which of the following is an example of a parasite that could be harmful if eaten?
- 7) What in the human body helps fight off bad microorganisms?
- 8) What can be applied to protect crops from insects or disease-causing organisms, and who should use them?
- 9) What are some physical objects that may be found in the garden and that could hurt you?
- 10) What should you do if you see sharp objects in the garden?

Quiz questions for elementary section three of online module

- 1) How can drinking from hoses make people sick from fruits and vegetables?
- 2) Why should fruits and vegetables not be set in soil after taken off the vine?
- 3) Are all microorganisms harmful?
- 4) Which of the following is NOT a risk associated with animals in the garden?
- 5) Where should fruits and vegetables be placed after picked from the vine?
- 6) Why should most produce be rinsed after it has been collected?
- 7) When should hands be washed?
- 8) What is the length of time needed for hands to be lathered once soap has been applied?
- 9) What chemicals are used by adults to keep insects away from the garden?
- 10) How should gardening tools be stored when not in use?

Quiz questions for elementary section four of online module

- 1) What should we do if rotting or damaged fruits and vegetables are found?

- 2) What should NOT be done with most fruits and vegetables before storing them?
- 3) What other surfaces need to be kept clean to keep fruits and vegetables safe?
- 4) After washing fruits and vegetables after storage, how should they be dried?
- 5) How will fruits and vegetables that are not good for eating look?
- 6) What will fruits and vegetables look like that are good for eating?
- 7) Why should some fruits and vegetables be washed before storing?
- 8) What types of hazards has this learning module emphasized?
- 9) Why are fruits and vegetables washed before eating them?
- 10) How will you know where fruits and vegetables should be stored?

**Figure 4.1. Quiz questions for all sections of elementary online modules.**

Quiz questions for section one of university module.

- 1) What are three types of hazards that fresh produce are exposed to?
- 2) What percent of reported foodborne illnesses were attributed to produce related items?
- 3) About what is the typical size of a microorganism?
- 4) Which of the following is a harmful bacteria if ingested by humans?
- 5) Which of the following is a common virus found on produce items?

Quiz questions for section two of university module.

- 1) The final food safety plan that brings together all of the other food safety aspects is called the \_\_\_\_\_ plan.
- 2) Which of the following is NOT a biological hazard in pre-harvest produce food safety?
- 3) Why should soil be tested prior to planting in fields?
- 4) How many days prior to harvest must raw manure be applied according to the National Organic Standards?
- 5) What is one type of toxin found naturally in apples that can cause illness if ingested?
- 6) Which of the following is NOT a physical hazard that could be found in the field?
- 7) What should be done to reduce chances of physical hazards from occurring?
- 8) What is the best way to start implementing an effective food safety plan?
- 9) What is not a hazard to worry about in pre-harvest produce food safety?
- 10) What should be done with chemicals when not being used by authorized individuals?

Quiz questions for section three of university module.

- 1) What do we call the “Start-to-finish” approach in produce food safety?
- 2) Which of the following is NOT a post-harvest produce food safety hazard?
- 3) Why is it important to keep harvesting bins off of the ground?
- 4) How should preparation surfaces be to reduce microbial growth?
- 5) What are specific things to look for when keeping the processing area sanitary?
- 6) How should spoiled or rotten produce items be discarded or disposed of?
- 7) When storing produce, what saying is used to maximize product usage and minimize wastes?
- 8) If produce is stored at room temperature, what should the conditions be?
- 9) How should chemicals be applied in post-harvest produce food safety?
- 10) What is a physical hazard that can arise during post-harvest produce food safety?

Quiz questions for section four of university module.

- 1) What is the best way to wash your hands when handling produce?
- 2) According to the Centers for Disease Control and Prevention (CDC), about what percent of foodborne disease are linked to poor hand washing?
- 3) When washing hands, how long should they be lathered in soap?
- 4) What is a fomite?
- 5) Which of the following is a group of regulations related to produce food safety?
- 6) Why is it important to follow food regulations?
- 7) Which of the following groups of individuals are more likely to become ill from contaminated produce items?

- 8) Do NOT go to work if you have which of the following symptoms?
- 9) What type of towels, if available, should be used when washing hands?
- 10) What regulation was just modified in 2013 that has given the Food and Drug Administration (FDA) more power than they previously had over produce processors and producers?

**Figure 4.2. Quiz questions for all sections of university online modules.**

**Table 4.1. Mean pre- and post- module scores of 1<sup>st</sup> – 3<sup>rd</sup> and 6<sup>th</sup> – 8<sup>th</sup> grade students.**

<b>Introduction/Importance</b>	<b>Before Module Scores (n = 43)</b>	<b>After Module Scores (n = 43)</b>
1 <sup>st</sup> – 3 <sup>rd</sup> Grade (n = 26)	98.19 <sup>a</sup>	99.19 <sup>b</sup>
6 <sup>th</sup> – 8 <sup>th</sup> Grade (n = 17)	98.18 <sup>a</sup>	99.29 <sup>b</sup>
Composite Grades	98.19 <sup>a</sup>	99.23 <sup>b</sup>
<b>Pre-harvest hazards/hazard prevention</b>		
1 <sup>st</sup> – 3 <sup>rd</sup> Grade (n = 26)	88.74 <sup>a</sup>	100.0 <sup>b</sup>
6 <sup>th</sup> – 8 <sup>th</sup> Grade (n = 17)	89.29 <sup>a</sup>	100.0 <sup>b</sup>
Composite Grade	88.95 <sup>a</sup>	100.0 <sup>b</sup>
<b>Post-harvest hazards/hazard prevention</b>		
1 <sup>st</sup> – 3 <sup>rd</sup> Grade (n = 26)	92.48 <sup>a</sup>	100.0 <sup>b</sup>
6 <sup>th</sup> – 8 <sup>th</sup> Grade (n = 17)	92.94 <sup>a</sup>	100.0 <sup>b</sup>
Composite Grade	92.66 <sup>a</sup>	100.0 <sup>b</sup>
<b>Good Handling Practices/Personal Hygiene/Storage Practices</b>		
1 <sup>st</sup> – 3 <sup>rd</sup> Grade (n = 26)	94.41 <sup>a</sup>	100.0 <sup>b</sup>
6 <sup>th</sup> – 8 <sup>th</sup> Grade (n = 17)	96.0 <sup>a</sup>	100.0 <sup>b</sup>
Composite Grade	95.02 <sup>a</sup>	100.0 <sup>b</sup>

\*Means with different letters (a, b) indicate significance ( $P < 0.05$ ) within each row.

**Table 4.2. Mean pre- and post- module scores for two university groups of farm workers.**

<b>Introduction/Importance of Produce Training</b>	<b>Before Module Scores (n = 25)</b>	<b>After Module Scores (n = 25)</b>
University 1 (n = 14)	98.21 <sup>a</sup>	100.0 <sup>b</sup>
University 2 (n = 11)	98.0 <sup>a</sup>	100.0 <sup>b</sup>
Composite University	98.12 <sup>a</sup>	100.0 <sup>b</sup>
<b>Pre-harvest hazards and Hazard Prevention</b>		
University 1 (n = 14)	94.71 <sup>a</sup>	100.0 <sup>b</sup>
University 2 (n = 11)	96.45 <sup>a</sup>	100.0 <sup>b</sup>
Composite University	95.48 <sup>a</sup>	100.0 <sup>b</sup>
<b>Good Agricultural Practices/ Good Handling Practices</b>		
University 1 (n = 14)	98.21 <sup>a</sup>	100.0 <sup>b</sup>
University 2 (n = 11)	97.73 <sup>a</sup>	100.0 <sup>b</sup>
Composite University	98.0 <sup>a</sup>	100.0 <sup>b</sup>
<b>Personal Hygiene/ Cross-Contamination</b>		
University 1 (n = 14)	100.0 <sup>a</sup>	100.0 <sup>a</sup>
University 2 (n = 11)	100.0 <sup>a</sup>	100.0 <sup>a</sup>
Composite University	100.0 <sup>a</sup>	100.0 <sup>a</sup>
<b>Regulations Associated with Fresh Produce</b>		
University 1 (n = 14)	98.93 <sup>a</sup>	100.0 <sup>b</sup>
University 2 (n = 11)	99.27 <sup>a</sup>	100.0 <sup>b</sup>
Composite University	99.08 <sup>a</sup>	100.0 <sup>b</sup>

\*Means with different letters (a, b) indicate significance ( $P < 0.05$ ) within each row.



## CHAPTER 5: CONCLUSION

This project has been successful in developing two online fresh produce food safety modules that increased knowledge in food safety. The pilot study showed statistically significant results for increased knowledge in both populations tested, with the exception of the personal hygiene section of the university module. The pre-harvest hazard section showed significant differences in the university populations, while statistical significant differences for elementary knowledge were observed in all module sections. Survey results from instructors allowed for more comprehensive final modules. User modules and additional activities developed from this research project will be shared throughout the state to partners including FFA and 4-H educators, state agencies that are involved in Farm to School programs, school district and child nutrition program administrators, and higher education farm managers. Beyond Iowa, the content developed in this study will be shared with food safety extension specialists that are actively engaging in farm outreach efforts. Material developed from this project can be used to educate local schools, community gardeners, community colleges, and universities on safe practices associated with production of fresh produce.

To be decrease produce safety risks around the United States, online trainings need to meet the needs of workers. Our online training is currently being translated to Spanish to reach a wider population. A large population of garden and field workers speak Spanish, using English as a second language. Greater retention will be seen in Spanish speaking workers, reducing language barrier issues. This project has resulted in the development of specialized food safety trainings that will change behaviors of produce growers in school gardens and university farms. Implementing effective training

in schools and universities will help mitigate foodborne illness risks. To have a behavioral change occur for garden workers while working around the garden, more schools and universities must implement online training curriculums to educate the workers on the many potential hazards of working in or around school gardens or university farms. This project has taken the first steps in developing a fully comprehensive online training program for school gardens and university farms. By using our developed modules, quizzes, additional activities, and instructor guides, school gardens and university farms can receive a well-rounded learning program over the risks and preventative measures required to reduce foodborne illness risk in fresh produce items.